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NE 21, 1943
LUME 32, No. 13

AMERICAN DYESTUFF REPORTER

JUN 28 1943
DETROIT

Learning a Lesson in Dyestuffs

TODAY Mary wears a uniform at a drill press, and she wants it to stay attractive! But it must outlast dozens of *hard* launderings to remove ingrained dirt, rust, oil, grime and perspiration.

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BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

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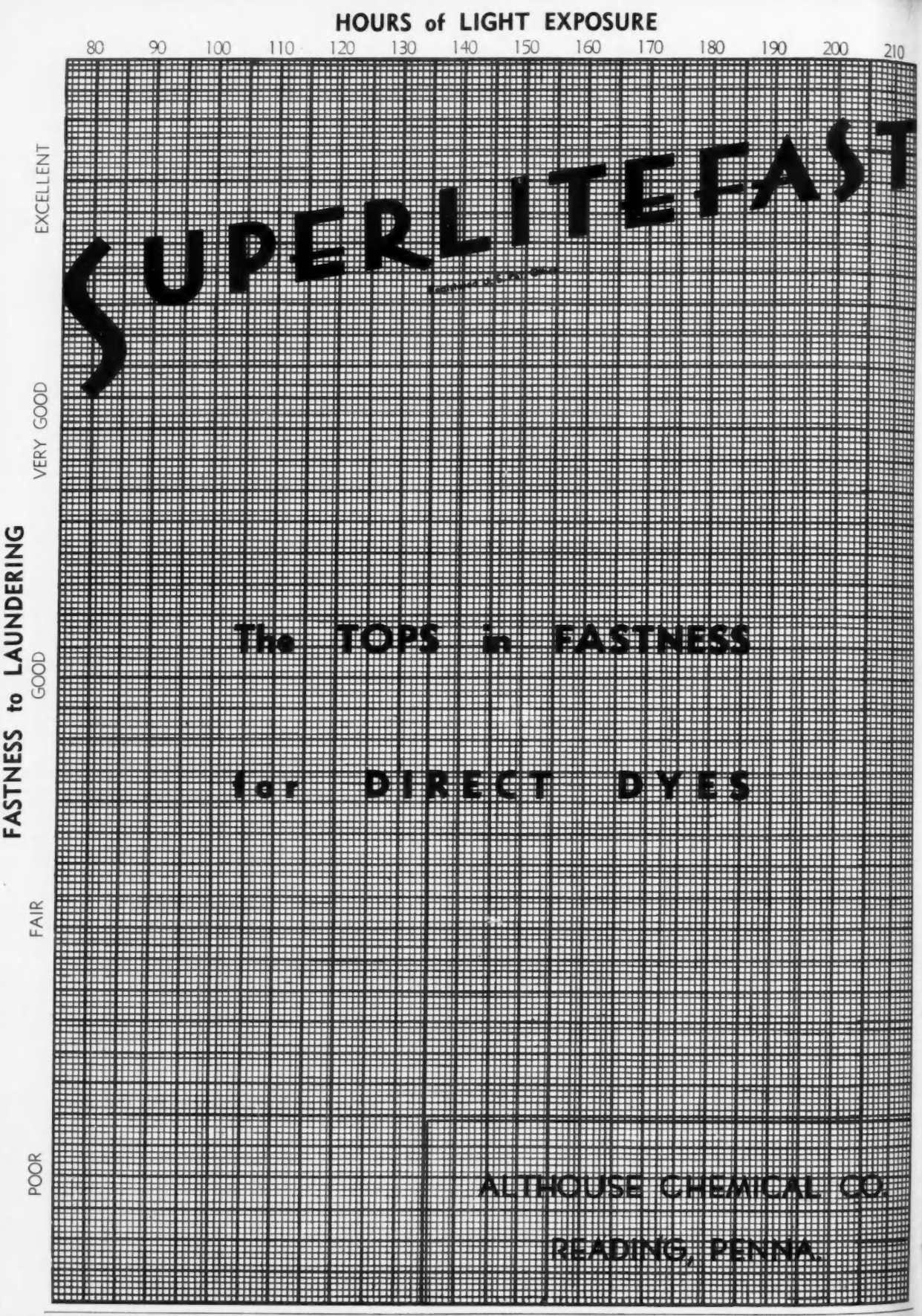

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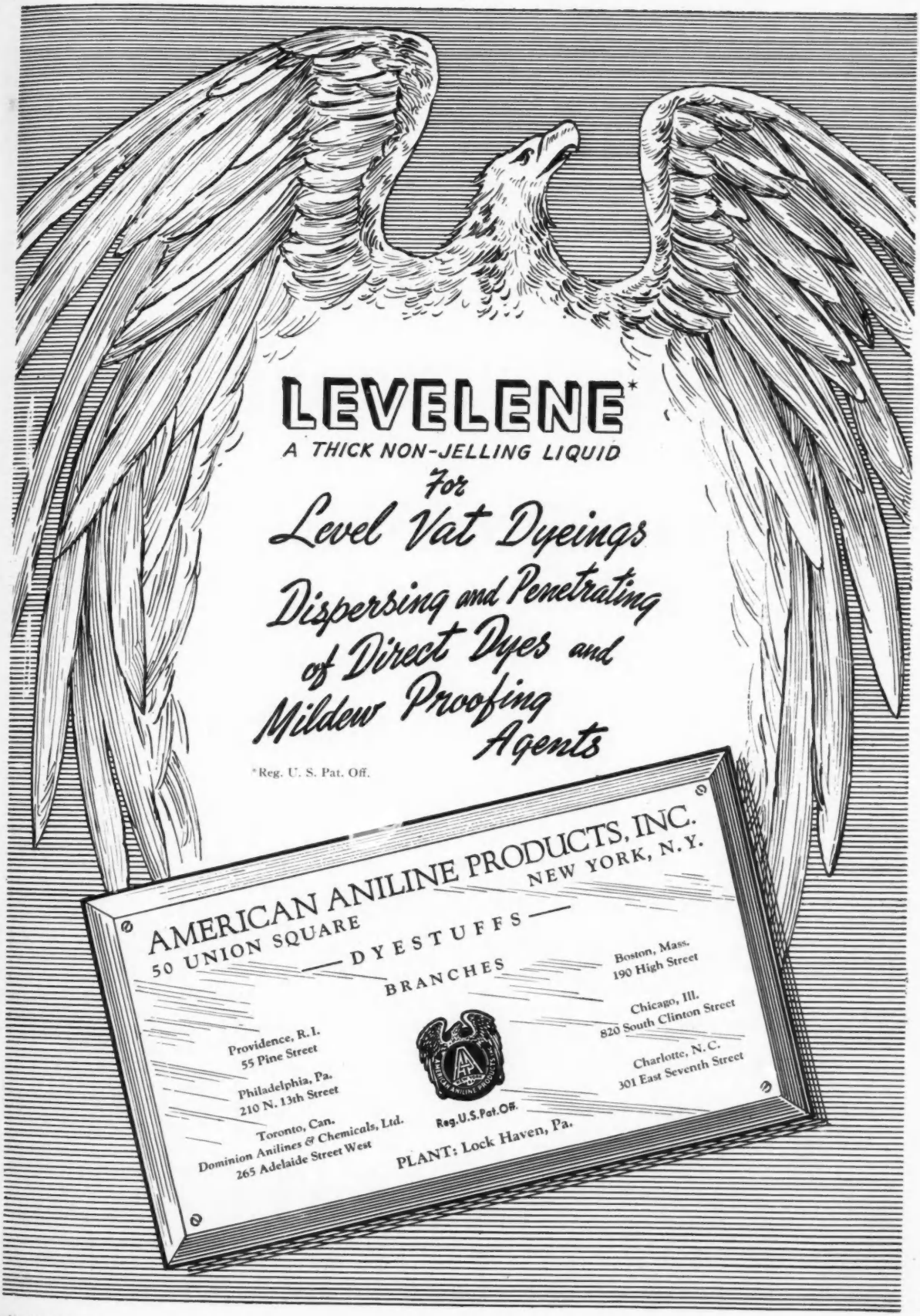
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Eastman Blacks are part of an extensive line of dyes developed by Eastman scientists, who for many years have specialized in colors for use with cellulose acetate products. For information on Eastman Acetate Dyestuffs consult our New York Sales Representative: F. L. Bume, 10 East 40th Street, New York, N. Y., or write TENNESSEE EASTMAN CORPORATION (Subsidiary of Eastman Kodak Company), KINGSPORT, TENNESSEE.

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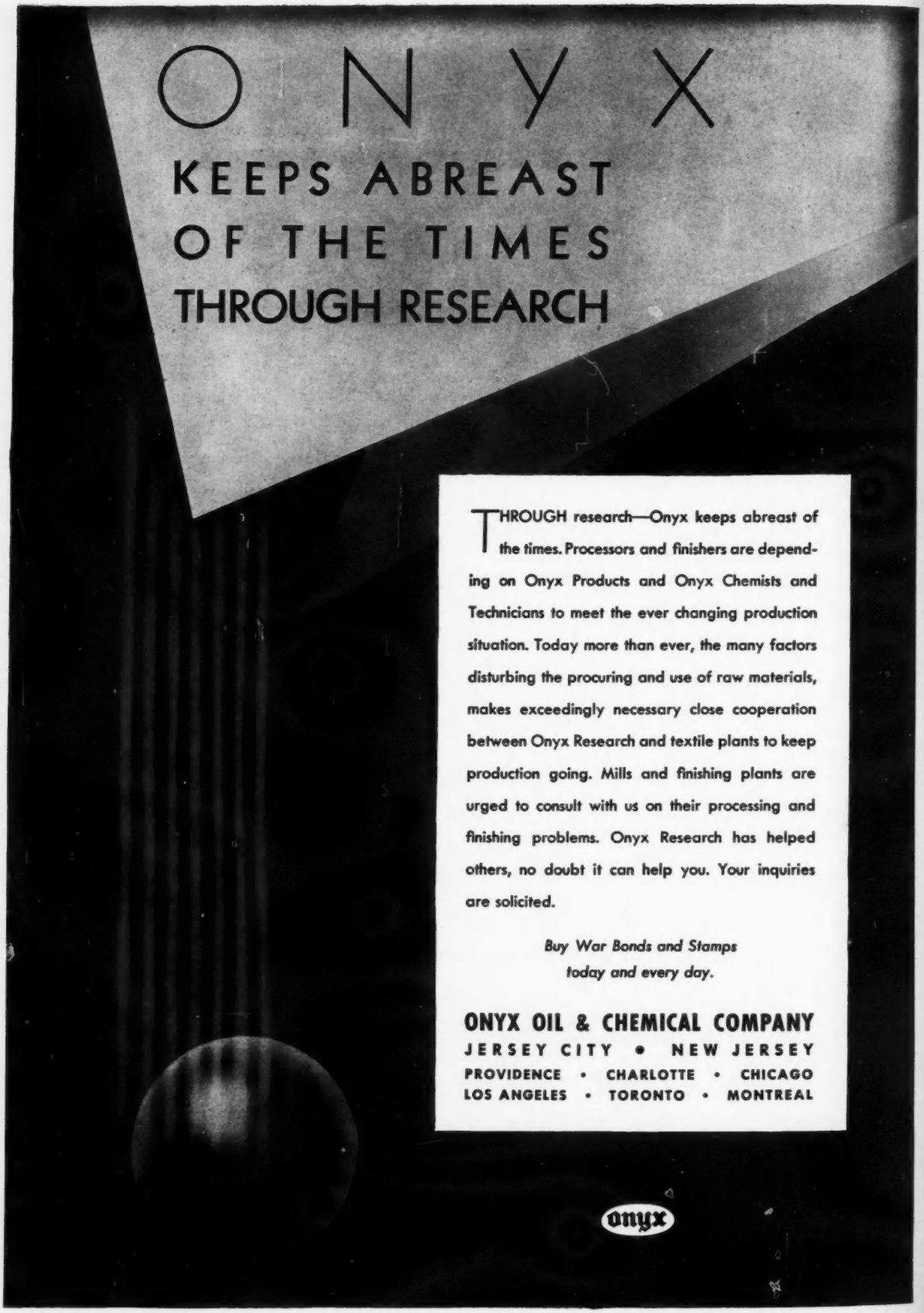
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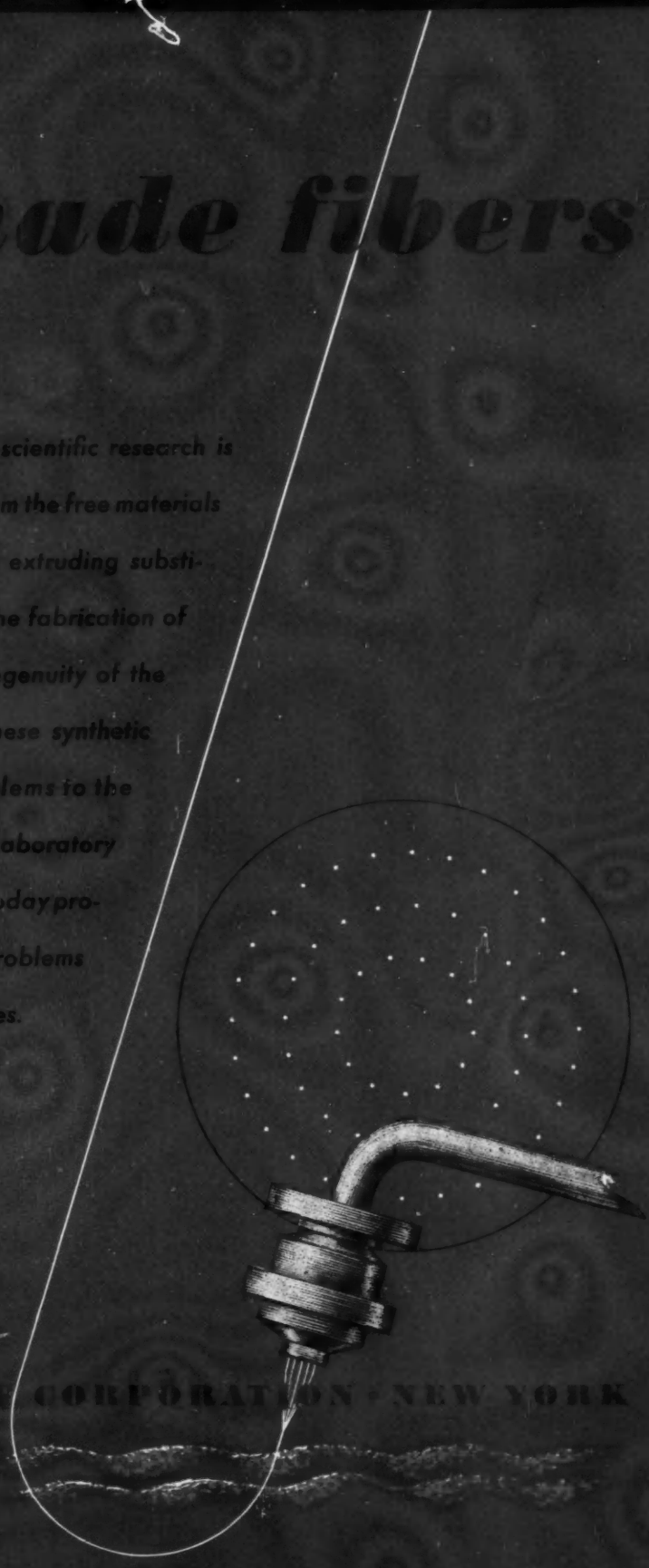

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No. 10 of a series—from our confidential files on the new "CROWN" Tested Plan

If you were out to make a dress fabric hand-washable . . . resistant to shrinking . . . resistant to fading...how would you do it?

Here's proof that a quick and satisfactory way is through the CROWN Tested Plan. In discussing this problem with a converter we know, we found that his chief need was dye formulas for his finisher. These we supplied.

When the first sample was tested, it was well-constructed, well-finished, passed tests for light fastness and hot pressing . . . but there was color "bleeding" in the wash test.

Yet we knew from experience that our dye formulas should give satisfactory results. Where . . . or what . . . was the trouble?

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If you work with rayon...constructing, dyeing or finishing . . . the CROWN Tested Plan can help you achieve better performance for your fabrics. May we prove it?

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Ever get on the merry-go-round . . . the vicious cycle of price-cutting? Then you know there's neither profit nor satisfaction in that kind of competition. When fabric quality drops . . . keeping pace with prices . . . soon it's no bargain at *any* price.

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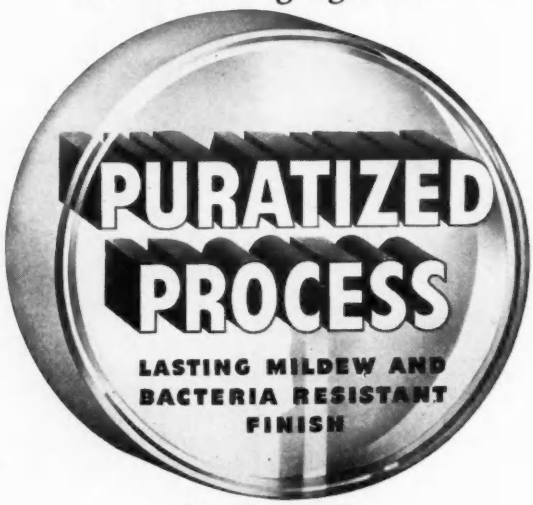

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6. Does not increase flammability.
7. Does not alter feel or hand of materials.
8. Does not add toxic or irritating properties.
9. Does not affect porosity.
10. Inexpensive to apply and no additional plant equipment is required for application.

(All claims made for treated materials have been substantiated by government and independent scientific tests and researches. Facts upon request.)

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OUT OF the cauldrons of war will one day come the works of peace, improved and renewed by their baptism of fire. "Continuous Process" Rayon Yarn, Industrial's great contribution to rayon progress, is one such product. Ideally suited to war needs because of its unexampled uniformity and virtual freedom from knots and broken filaments, this yarn, in parachutes, is dropping bombs on the enemy; as wire covering, it is insulating the hearts of submarines and destroyers; in tires, it will keep bombers and half-tracks and gun carriers rolling.

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Meantime, Industrial's famous Spun-lo Knit Cloth for Undies, and as much of Industrial's quality yarns as can be spared from the works of war, are serving to keep up the morale of the army on the home front by supplying wearables for workers, and clothing for civilian needs.

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Manufacturers of "CONTINUOUS PROCESS" RAYON YARN and Spun-lo KNIT RAYON CLOTH
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DON'T BE PENNY-WISE AND TON-FOOLISH ABOUT SCRAP!

IT'S easy to salve your salvage conscience by turning in the junk you'd been meaning to get rid of. *But this is not enough!* To end the shortage of heavy steel scrap you've got to dig deeper. Mills are going to need about 26,000,000 tons of purchased scrap this year! To make sure that the men we've sent to war will have the weapons they need, you've got to get rid of every piece of idle "slacker" metal in your plant. Don't hang on to something, just because you may need it some time next year or after the war. Sell it—either as scrap or as second hand equipment.

RUN YOUR SCRAP PROGRAM ACCORDING TO THIS RULE:

If it hasn't been used for three months, and if some one can't prove that it's going to be used in the next three—sell it—or scrap it! Scrap and used equipment dealers pay well for usable machinery and materials.

CAN'T GET ENOUGH COPPER

Shortest of all is copper, and officials say this critical shortage will continue for the duration. Copper refineries are not operating at full capacity . . . when they should be running wide open! Who knows how long that one scarcity may delay the final big push?

So round up that copper scrap. Brass and bronze, too. And here's a tip—don't throw it all helter-skelter on one pile. It takes too long to sort, and in addition, you're likely to get a price equal to the lowest grade in the pile. Don't just separate different metals . . . it's to your advantage to *segregate* them by alloys, if you possibly can.

DEDUCT VALUE FROM YOUR INCOME TAX

Remember . . . if the item you scrap still appears on your books, it can be deducted. Otherwise it cannot. This is a matter for your accountant or attorney to decide. Even if not deductible, don't hoard it. For used machinery especially there's a big and continuing demand. *Somebody needs it—badly!*

It all boils down to this . . . if you hang on to tons of good steel . . . if you refuse to part with useless machinery . . . you're being a scrap slacker!

You're putting pennies before patriotism and making it just that much harder for us to win the war.

GET TOUGH AND CLEAN UP

Make your scrap program a continuous effort. Put a go-getter in charge of it . . . somebody with real authority. Have him go through the plant at regular intervals with a piece of chalk or can of paint and mark what's to go. Whether it's junk or usable equipment, you'll get a fair price for it. And you'll get the warm feeling of having done something *extra* for victory!

BUSINESS PRESS INDUSTRIAL SCRAP COMMITTEE

ROOM 1310, 50 ROCKEFELLER PLAZA, N. Y. C.

If you have done a successful salvage job at your plant, send details and pictures to this magazine.

SEND FOR PRIMER OF INDUSTRIAL SCRAP TO HELP YOU TACKLE THE SALVAGE PROBLEM

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USE LEVANA IN THE DYE BATH

Soldiers, sailors, marines are tough on equipment. Think of the "wear and tear" your government woolens must undergo in the service of the armed forces! To insure *maximum* strength — add Levana to the dye bath. This *original* Sandoz formula protects wool fibers against the action of alkalies . . . steps up the tensile strength of the finished fabric!

Levana prevents felting and shrinking . . . preserves the "soft hand" of fine woolens. Economical and easy to use . . . Levana is readily soluble in water. Long used by leading textile mills, today Levana is in greater demand than ever — when military requirements call for greater wear and durability in every yard of government goods.

IMPORTANT NOTICE!

DYERS OF RAW STOCK

✓ Levana improves weaving efficiency

✓ Insures highest tensile strength

DYERS OF YARNS and PIECE GOODS

✓ Levana improves level dyeing

✓ Insures tensile strength

✓ Prevents felting and shrinking

Only Sandoz Makes Levana

Write today for a WORKING SAMPLE OF LEVANA. Also ask for Catalog No. 33-A. Or — if you have a specific problem that calls for "on-the-spot" action — Sandoz technicians are available to visit your mill. They are in a position to benefit you by the experience gained in years of plant work.

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JUNE 21, 1943

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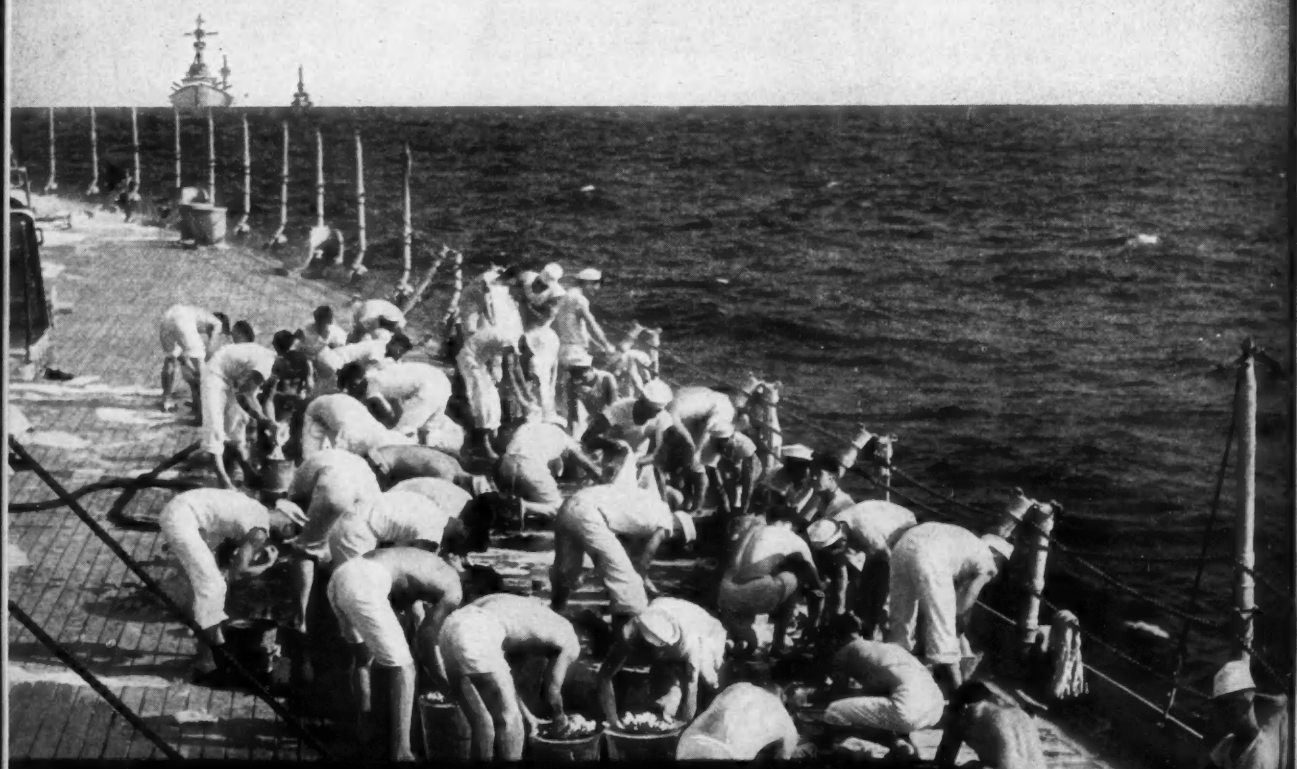
Nacconol NR—the economical surface-active detergent—is now on active duty with the Navy. Lathering freely and washing efficiently in salt water, Nacconol NR materially reduces the amount of fresh-water storage . . . makes spotless housekeeping aboard our fighting ships less burdensome for he-men.



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AMERICAN
DYESTUFF REPORTER

VOLUME 32 JUNE 21, 1943 NUMBER 13

A Study of the Neutralization of Carbonized 32 Oz.

OLIVE-DRAB OVERCOATING

KERMIT S. LaFLEUR

A LARGE portion of Government olive-drab overcoating is woven from stock dyed with the following colors:

Eriochrome Flavine A
Alizarine Blue-Black BA
Alizarol Brown RH
Alizarine Garnet RA

Pieces dyed with Brown RH redden considerably, those with Flavine A greatly, when they are carbonized with sulfuric acid. Within the extremes of mill carbonizing practice, the overcoating dyed with these colors reddens progressively (an effect almost quantitatively measurable by eye) as the per cent acid increases.

The comparative, variable redness of insufficiently neutralized overcoating pieces has made the adequate neutralization of this fabric imperative. This situation atones in part for the off-shade worries which the Flavine A, especially, caused at first, and may even be considered an argument for the continued use of the color, since it exerts a correcting influence on a process in which faulty manipulation is evidently quite common, though seldom obvious.

The conclusions drawn from the experiments which follow will help in making adjustments and corrections in existing neutralizing methods.*

Initial experiments were run with "red" and "green" sets of ten swatches each, cut from headings selected as extremes from current regular carbonized goods. The "green" is of course a relative expression, and actually is much redder than equivalent pieces of lower acid content:

Piece	*Initial Acid Content***
10934 (Red)	5.57%
9756 (Green)	4.89%

The swatches were neutralized for 10, 20, 30 and 45 minutes, 1 hour, 1¼, 1½, 1¾, 2, and 2½ hours in a launderometer, using a 1/15 bath @ 70°F. Each swatch was passed through a wringer between a doubled sheet of paper towelling, dried, conditioned, and the per cent residual acid was determined. The per cent acid was then plotted against the time intervals (Figs. 1-10).

For convenience, the orientation experiments (Groups I and II) were run with 0.25%, 0.50%, and 0.75% solutions of soda ash,† and these percentages were converted roughly into expressions relative to the amount theoretically required for neutralization.‡ Greater refinements in calculations were introduced in succeeding experiments.

---

* The maintenance of uniform acidity in the carbonizing bath is postulated in any attempt to improve neutralizing procedures.

** All per cent acid figures are expressed as H_2SO_4, and are the average of at least two determinations obtained by a modification of the Barritt pyridine method outlined below:

A two gram sample is placed in a 500cc. Erlenmeyer flask, and 10ccs. of 10% solution of pyridine (by volume) are added. The pyridine wets out the sample thoroughly on careful shaking. 200 ccs. of water at 100°F. are added. The contents of the flask are swirled, and allowed to stand for one hour. The entire solution is then titrated in the presence of the sample with $\frac{N}{10}$ sodium hydroxide, using phenolphthalein as an indicator.

The pyridine method provides a short, convenient means of testing for per cent acid in the routine examination of a large number of samples, and yields sufficiently accurate, comparative results if conditions are kept strictly uniform. The average per cent error experimentally determined on samples to which 0.25 to 6.00% acid was added was 2.7% (on low side).

† Logically the alkali to use because it is in general use as a scouring assistant in textile mills, is comparatively mildly alkaline, is economical, and available in quantity.

‡ The neutralization of sulfuric acid carbonized pieces with soda ash in a closed system is expressed in the following reaction:

$$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$$

1 part : 1 part
106 : 98

106 : 98 = x : 5.57 x = 6.03% soda ash theoretically required to neutralize pc. 10934.

106 : 98 = x : 4.89 x = 5.29% soda ash theoretically required to neutralize pc. 9756.

1) 0.25% solution of 150ccs. = .375 gms. of soda ash per 10 gm. swatch = 3.75%.

2) 0.75% solution of 150ccs. = 1.125 gms. of soda ash per 10 gm. swatch = 11.25%.

3) 0.50% solution of 150ccs. = .750 gms. of soda ash per 10 gm. swatch = 7.50%.

Assuming, for convenient expression, that 6.0% of soda ash is necessary to neutralize these pieces in a closed sytem, we have the following rough relationhips between the actual and required amounts of soda ash:

3.75/6.00 = 62½% of the required amount of soda ash.
11.25/6.00 = 187½% of the required amount of soda ash.
7.50.6.00 = 125% of the required amount of soda ash.

NEUTRALIZING EXPERIMENTS

Group I—The amount of soda ash needed for adequate neutralization.

Set I—Problem. The effect of using approximately 62½% of the required amount of soda ash.

	% Acid	Neutralizing Time	% Acid	
	1. 2.38	10′	1. 1.88	
	2. 2.43	20′	2. 1.83	
	3. 2.21	30′	3. 1.78	
	4. 2.13	45′	4. 1.74	
	5. 2.09	1 hr.	5. 1.73	Pc. 9756
Pc. 10934	6. 2.11	1¼	6. 1.68	(Green)
(Red)	7. 2.03	1½	7. 1.69	
	8. 2.13	1¾	8. 1.70	
	9. 2.04	2	9. 1.64	
	10. 2.02	2½	10. 1.48	

Conclusion—The use of approximately 62½% of the required amount of soda ash for neutralizing in a closed system is an entirely inadequate treatment.

Initial acid content differences are retained. (Fig. 1)

Set II—Problem—The effect of using approximately 187½% of the required amount of soda ash.

	% Acid	Neutralizing Time	% Acid	
	1. 0.52	10′	1. 0.36	
	2. 0.17	20′	2. 0.12	
	3. 0.05	30′	3. 0.03	
	4. 0.04	45′	4. 0.03	
Pc. 10934	5. 0.04	1 hr.	5. 0.02	Pc. 9756
(Red)	6. 0.03	1¼	6. 0.03	(Green)
	7. 0.02	1½	7. 0.01	
	8. 0.02	1¾	8. 0.01	
	9. 0.02	2	9. 0.00	
	10. 0.01	2½	10. 0.01	

Conclusion—The use of approximately 187½% of the required amount of soda ash produces a near-neutral piece in ½ hour under the experimental conditions. There appears to be no reason why such a large excess of alkali should be used.

Initial acid content differences are retained. (Fig. 2)

Set III—Problem—The effect of using approximately 125% of the required amount of soda ash.

	% Acid	Neutralizing Time	% Acid	
	1. 0.99	10′	1. 0.86	
	2. 0.67	20′	2. 0.50	
	3. 0.46	30′	3. 0.34	
	4. 0.36	45′	4. 0.23	
Pc. 10934	5. 0.26	1 hr.	5. 0.17	Pc. 9756
(Red)	6. 0.19	1¼	6. 0.15	(Green)
	7. 0.19	1½	7. 0.11	
	8. 0.17	1¾	8. 0.09	
	9. 0.14	2	9. 0.08	
	10. 0.11	2½	10. 0.07	

Conclusion—Sufficient neutralizing takes place in about 1 hour's time when approximately 125% of the required amount of soda ash is used in a closed system.

Initial acid content differences are retained. (Fig. 3)

Set IV—Problem—Are initial acid content differences retained in pieces neutralized in the same bath using approximately 125% of the required amount of soda ash?

	% Acid	Neutralizing Time	% Acid	
	1. 1.08	10′	1. 0.87	
	2. 0.69	20′	2. 0.50	
	3. 0.41	30′	3. 0.30	
	4. 0.25	45′	4. 0.21	
	5. 0.20	1 hr.	5. 0.17	Pc. 9756
Pc. 10934	6. 0.16	1¼	6. 0.13	(Green)
(Red)	7. 0.11	1½	7. 0.10	
	8. 0.10	1¾	8. 0.09	
	9. 0.08	2	9. 0.08	
	10. 0.07	2½	10. 0.07	

Conclusion—Initial acid content differences are retained at first. After 2 hours' neutralizing, the curves plotted from the data merge. (Fig. 4)

*Set V—Problem—The effect of using approximately the required amount of soda ash. (Average of two sets.)**

	% Acid	Neutralizing Time	% Acid	
	1. 1.16	10′	1. 1.04	
	2. 0.84	20′	2. 0.69	
	3. 0.68	30′	3. 0.50	
Pc. 10934	4. 0.52	45′	4. 0.39	Pc. 9756
(Red)	5. 0.42	1 hr.	5. 0.35	(Green)
Pc. 8874	6. 0.36	1¼	6. 0.28	Pc. 9404
	7. 0.35	1½	7. 0.25	
	8. 0.36	1¾	8. 0.23	
	9. 0.32	2	9. 0.20	
	10. 0.30	2½	10. 0.19	

Conclusion—Neutralizing with approximately the required amount of soda ash is not so effective as the use of slightly more than the required amount. (Fig. 5)

Set VI—Problem—The effect of neutralizing with water only.

	% Acid	Neutralizing Time	% Acid	
	1. 3.54	10′	1. 3.20	
	2. 3.26	20′	2. 2.61	
	3. 2.70	30′	3. 2.68	
	4. 2.39	45′	4. 2.55	
Pc. 10934	5. 2.54	1 hr.	5. 2.07	Pc. 9756
(Red)	6. 2.07	1¼	6. 2.18	(Green)
	7. 1.83	1½	7. 2.11	
	8. 1.83	1¾	8. 1.86	
	9. 1.66	2	9. 1.77	
	10. 1.38	2½	10. 1.60	

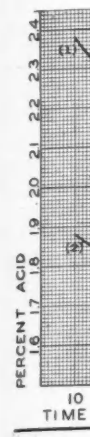
These results were too erratic to plot as separate curves. The average was plotted:

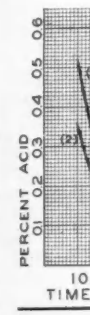
Average % Acid
1. 3.37
2. 2.94
3. 2.69
4. 2.47
5. 2.31
6. 2.13
7. 1.97
8. 1.85
9. 1.72
10. 1.49

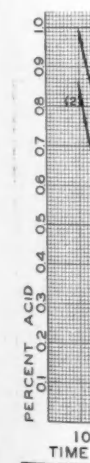
Conclusion—Water neutralization is not practicable. It is a lengthy operation, and gives inadequate results. (Fig. 6)

All of the swatches in the first five sets were wet out in a 0.25% solution of Nacconol NR and entered into the neutralizing bath without squeezing. The assumption that no acid was lost, and that the system could be considered as a closed one, was not substantiated by later experiments which indicated a 4.4% acid loss during this treatment. The relative expressions of the amounts of soda ash used (62½%, 187½%, and 125%) are therefore low.

* Results of the first set (pcs. 10934 & 9756) made a checking of data with a second (pcs. 8874 & 9404) desirable. Pc. 8874 had an initial acid content of 6.33%; pc. 9404, 5.33%.







Effect of Using Approximately 62½% of the Required Amount of Soda Ash.

SET I

Curve 1: Pc. 10194 (Red)—5.57% acid.
Curve 2: Pc. 9756 (Green)—4.89% acid.
Run Separately.

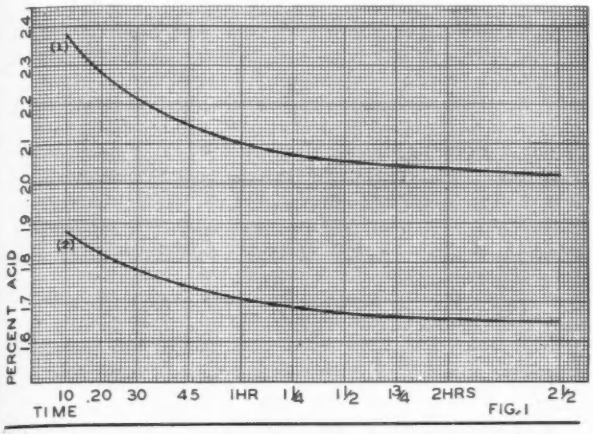


FIG. 1

Effect of Using Approximately 187½% of the Required Amount of Soda Ash.

SET II

Curve 1: Pc. 10194 (Red)—5.57% acid.
Curve 2: Pc. 9756 (Green)—4.89% acid.
Run Separately.

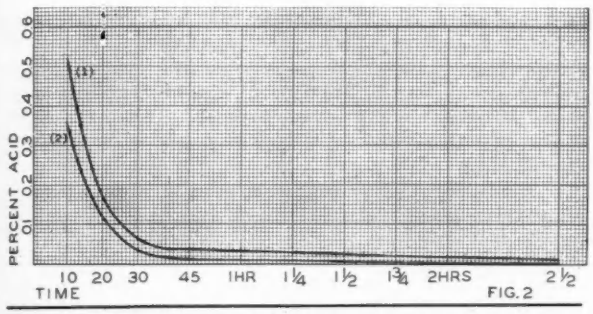


FIG. 2

Effect of Using Approximately 125% of the Required Amount of Soda Ash.

SET III

Curve 1: Pc. 10194 (Red)—5.57% acid.
Curve 2: Pc. 9756 (Green)—4.89% acid.
Run Separately.

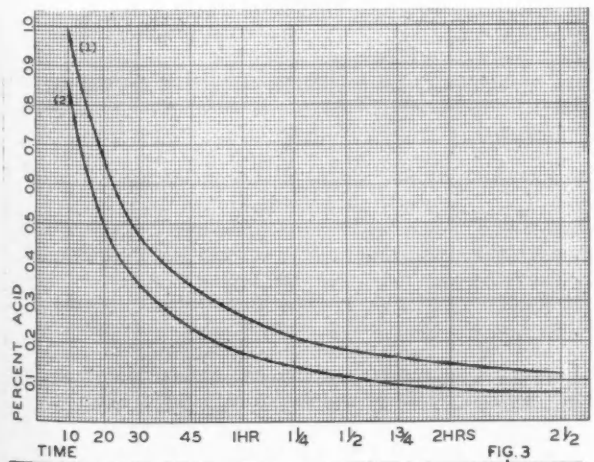


FIG. 3

Effect of Using Approximately 125% of the Required Amount of Soda Ash.

SET IV

Curve 1: Pc. 10194 (Red)—5.57% acid.
Curve 2: Pc. 9756 (Green)—4.89% acid.
Run Together.

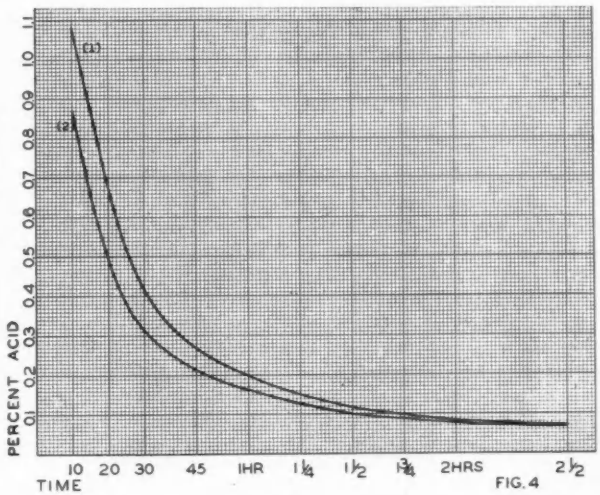


FIG. 4

Effect of Using Approximately the Required Amount of Soda Ash.

SET V

Curve 1: Pcs. 10194 and 8874 (Red)—5.57% and 6.33% acid.
Curve 2: Pcs. 9756 and 9404 (Green)—4.89% and 5.33% acid.

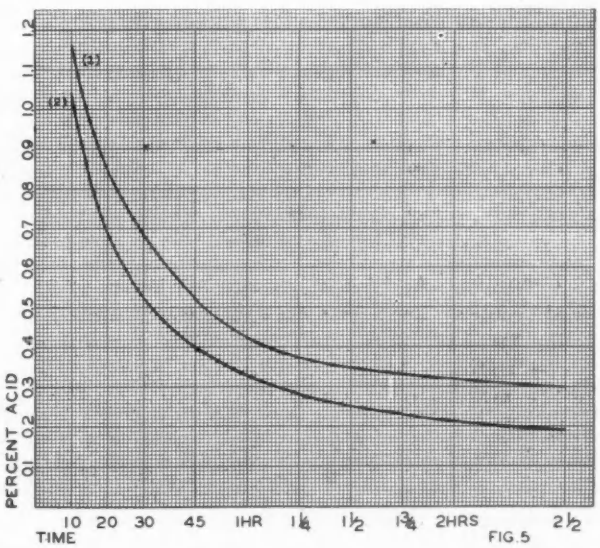


FIG. 5

An analysis of the curves of Sets III, IV, and V indicates that:

1) The greatest neutralizing effect occurs within the first 20 minutes.
2) The pieces are neutralized sufficiently in 1 hour's time.
3) The neutralizing action which takes place after 2 hours' time is negligible.

Effect of Water Treatment Only.
SET VI
Pc. 10194 (Red)—5.57% acid.
Pc. 9756 (Green)—4.89% acid.
Average Plotted

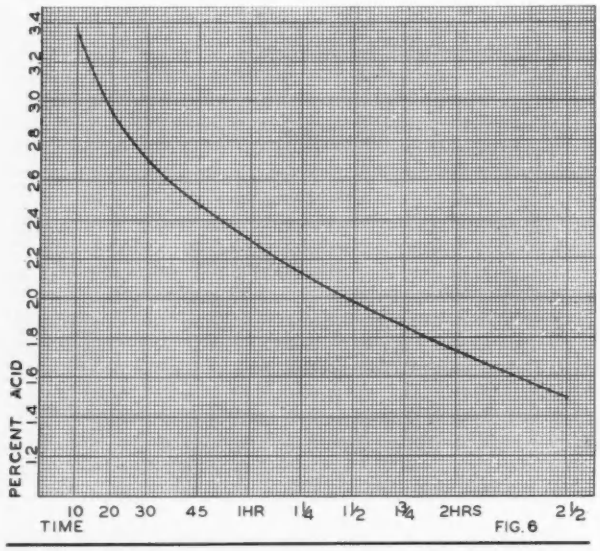


FIG. 6

Group II—The effects of water rinsing used in conjunction with soda ash.

Set VII—Problem—The effect of a preliminary rinse before using approximately 125% of the required amount of soda ash.

	% Acid	Neutralizing Time	% Acid	
	1. 0.78	10′	1. 0.69	
	2. 0.38	20′	2. 0.33	
	3. 0.30	30′	3. 0.19	
	4. 0.18	45′	4. 0.11	
Pc. 10934	5. 0.09	1 hr.	5. 0.07	Pc. 9756
(Red)	6. 0.09	1¼	6. 0.06	(Green)
	7. 0.07	1½	7. 0.05	
	8. 0.06	1¾	8. 0.04	
	9. 0.05	2	9. 0.03	
	10. 0.04	2½	10. 0.06	

Conclusion—An initial rinse materially lowers the initial acid content and improves subsequent neutralizing. (Fig. 7)

Set VIII—Problem—The effect of a final rinse after using approximately 125% of the required amount of soda ash.

	% Acid	Neutralizing Time	% Acid	
	1. 0.75	10′	1. 0.63	
	2. 0.46	20′	2. 0.39	
	3. 0.38	30′	3. 0.27	
	4. 0.30	45′	4. 0.20	
Pc. 10934	5. 0.25	1 hr.	5. 0.18	Pc. 9756
(Red)	6. 0.22	1¼	6. 1.16	(Green)
	7. 0.19	1½	7. 0.11	
	8. 0.18	1¾	8. 0.10	
	9. 0.17	2	9. 0.10	
	10. 0.17	2½	10. 0.08	

Conclusion—Rinsing does not further neutralize a piece which has been run 1 hour with 125% of the required amount of soda ash. If the piece has been in the neutralizing bath for a shorter period, rinsing does reduce the acid content somewhat. (Fig. 8)

Set IX—Problem—The effect of using initial and final rinses in conjunction with approximately 125% of the required amount of soda ash.

	% Acid	Neutralizing Time	% Acid	
	1. 0.65	10′	1. 0.49	
	2. 0.30	20′	2. 0.23	
	3. 0.21	30′	3. 0.18	
	4. 0.15	45′	4. 0.11	
Pc. 10934	5. 0.11	1 hr.	5. 0.08	Pc. 9756
(Red)	6. 0.11	1¼	6. 0.07	(Green)
	7. 0.08	1½	7. 0.06	
	8. 0.06	1¾	8. 0.04	
	9. 0.05	2	9. 0.03	
	10. 0.04	2½	10. 0.09	

Conclusion—Initial and final rinses are favored in neutralizing times up to 1 hour. Longer periods make the final rinse unimportant so far as lowering the acid content is concerned, but it is desirable in either case as a safeguard. (Fig. 9)

The swatches in the above sets (VII, VIII, and IX) were wet out in a 0.25% solution of Nacconol NR, and, where a preliminary rinse was indicated, were passed through a wringer. The assumption that this treatment would approximate an initial rinse was not substantiated by actual tests, for an average loss in cid content of only 13.7% occurred. An actual rinse would thus be much more effective.

Further rinsing experiments proved that prolonged rinsing removed acid from the higher acid content pieces, but not from the lower, as the following figures indicate:

Pieces	*Average % Acid Before Rinsing*	*Average % Acid After 2 hr. Rinse*
10934 and 9756	0.63 0.10	0.53 0.10

Recommendation—On the basis of the results of the preceding experiments, it is recommended that preliminary and final rinses (tentatively 10′ each) be used in conjunction with a neutralizing period of 1 hour, using more than the theoretically calculated required amount of soda ash.

Effect of Initial Rinse Before Using Approximately 125% of the Required Amount of Soda Ash.
SET VII
Curve 1: Pc. 10934 (Red)—5.57% acid.
Curve 2: Pc. 9756 (Green)—4.89% acid.

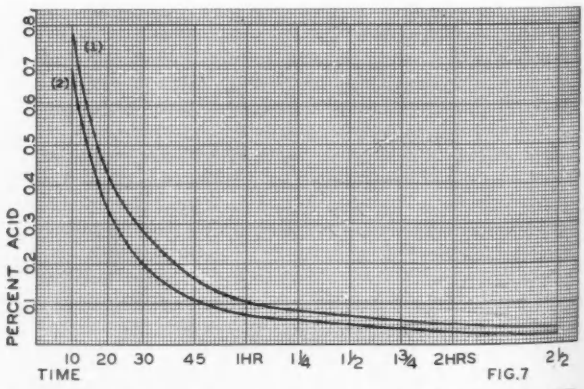


FIG. 7

Effect of Rinsing After Using Approximately 125% of the Required Amount of Soda Ash.
SET VIII
Curve 1: Pc. 10934 (Red)—5.57% acid.
Curve 2: Pc. 9756 (Green)—4.89% acid.

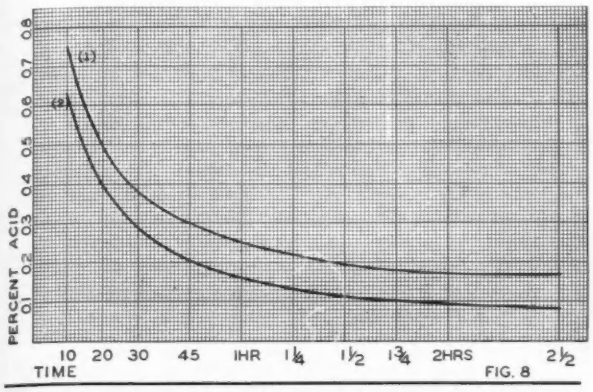


FIG. 8

Effect of Initial and Final Rinses While Using Approximately 125% of the Required Amount of Soda Ash.
SET IX
Curve 1: Pc. 10934 (Red)—5.57% acid.
Curve 2: Pc. 9756 (Green)—4.89% acid.

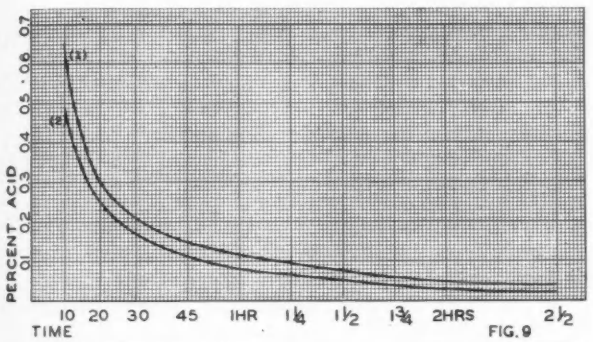


FIG. 9

Group III—The effect of the recommended treatment on a carbonized piece selected at random, using 110, 120, and 130% of the required amount of soda ash, figured on the actual acid content after the 10-minute rinse.*

Piece 6091 Initial % acid—5.30
% Acid after 10′ rinse—3.35

Set X	110% *Treatment*	120% *Treatment*	130% *Treatment*	
	% Acid	*% Acid*	*% Acid*	*Time*
	0.84	0.88	0.83	10′
	0.62	0.58	0.52	20′
	0.52	0.48	0.42	30′
	0.38	0.36	0.29	45′
	0.32	0.28	0.23	1 hr.
	0.28	0.25	0.20	1¼
	0.27	0.21	0.17	1½
	0.23	0.21	0.16	1¾
	0.21	0.21	0.12	2
	0.18	0.16	0.10	2½

Conclusion—Assuming that 0.25% of residual acid is an acceptable average, 125% of the required amount of soda ash should give satisfactory neutralization. (Fig. 10)

*This rinse was given in the launderometer with a 1/20 bath @ 70°F., and with no preliminary wetting out.

Effect of Using 110, 120 and 130% of the Required Amount of Soda Ash Based on the Per Cent Acid Content After an Initial Rinse.
SET X
Pc. 6091 — Initial % acid—5.30%
% acid after 10 min. rinse—3.35%

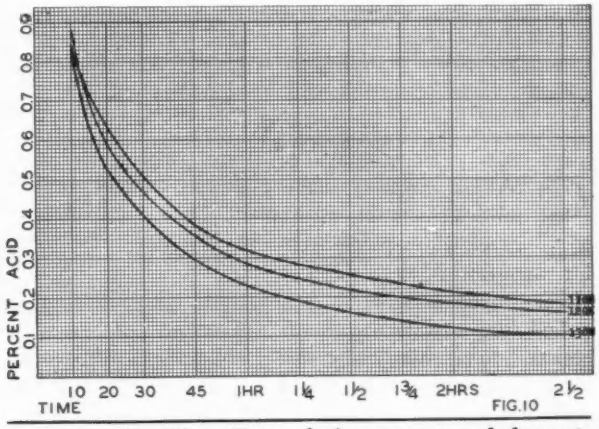


FIG.10

Group IV—The effect of the recommended treatment using 125% of the required amount of soda ash on 20 pieces selected at random.

	Piece	*Original % Acid*	*Final % Acid*
1.	6951	5.13	0.17
2.	6330	4.64	0.13
3.	7280	4.99	0.11
4.	6782	4.90	0.16
5.	6304	4.81	0.15
6.	6666	4.77	0.16
7.	7253	5.08	0.16
8.	6105	4.94	0.17
9.	7489	5.36	0.18
10.	5400	5.15	0.18
11.	5787	4.13	0.15
12.	6269	4.81	0.15
13.	6306	5.09	0.17
14.	6787	5.52	0.16
15.	7229	5.54	0.19
16.	5260	5.17	0.15
17.	6923	5.58	0.21
18.	6798	5.17	0.17
19.	7064	5.37	0.16
20.	6806	5.43	0.19
		Average 5.08%	Average 0.16%

Conclusion—125% the required amount of soda ash neutralizes pieces effectively under the experimental conditions, and represents a maximum figure.

Calculations—The average percent acid of our carbonized pieces is 5.38†. The average loss during the initial 10 minute rinse is 36%. Therefore, the average percent acid left to be neutralized is 3.24%, requiring 3.70% x 125% = 4.6% of soda ash on the weight of the goods.

4 pieces per neutralizer @ 60¾ yards. and 2.07 lbs. = 504 lbs.

4.6% x 504 lbs. = approximately 23 lbs. of soda ash required for satisfactory neutralization in 1 hour's time.

CONCLUSION

The foregoing data indicates that a 10 minute initial rinse, then 1 hour in neutralizing bath using 125% of the required amount of soda ash, followed by a 10 minute final rinse, gives the best all around conditions for commercial work.

† Average of 77 determinations.

The Color Fastness and Physical Properties of

WOOL AND RAYON GABARDINES[1]

HAZEL M. FLETCHER and HAZEL MARIE SCOTT SHERWOOD[2]

INTRODUCTION

STAPLE rayon yarns are woven extensively into fabrics simulating all wool. Cellulose acetate staple rayon with a permanent crimp is especially adaptable for wool-like fabrics. This rayon is often mixed with viscose rayon or wool as well as used alone.

Cellulose acetate rayon with a permanent crimp is resistant to crushing and creasing because of its resiliency. Its porosity and resilience add to its warmth as a fabric for clothing. It has a low affinity for moisture which makes it feel drier and dry more rapidly when wet than do the other rayon fabrics. It is decidedly free from shrinkage. Cellulose acetate rayon has advantages over wool in that it is not attacked by moths; it does not scratch or irritate sensitive skin; it can be laundered successfully; and it is less expensive than wool. When cellulose acetate rayon was introduced the dyer had difficulty in dyeing it, but those difficulties have been largely overcome.

Since rayon fabrics resembling wool are used so extensively because of their wide variety of textures, their comparative low cost, and the great demand for wool a comparison was made of all rayon and all wool gabardines.

MATERIALS

Nine viscose and cellulose acetate rayon mixed fabrics and nine all-wool fabrics were used in this study. The yarns in the rayons selected were a blend of cellulose acetate with a permanent crimp and viscose rayon fibers. Colors included white and light and dark shades of red, green, blue, and brown.

Selection of the fabrics from the two groups was made on the basis of similarity in weight, handle, appearance, and color. All were right twill gabardines except the white rayon which was a plain weave. The two white fabrics were included only in the study on color fastness because the white rayon was not of the same construction as the other fabrics. These materials were chosen from three wholesale establishments and one retail house. Table I gives data concerning their physical characteristics.

PROCEDURE

The percentages of the finishes were determined by the carbon tetrachloride and enzyme method given in A.S.T.M. (1).

The dyes were identified by following the tests outlined by Green and Clayton (2, 3).

The analysis of the mixed rayon fabrics was made by dissolving the acetate component in acetone as given in A.S.T.M. (1).

Each fabric was divided into three parts; one was retained as the control and the others were given special treatments. One part was dry-cleaned 30 times by a commercial firm which is a member of the National Dyers and Dry Cleaning Association. The fabrics were cleaned in Stoddard solvent with Sanitone detergent and were pressed in a flat steam press. After 10 and after 20 dry cleanings a six-inch length was cut off to make breaking strength tests along the warp.

The third part was cut into strips for breaking strength tests. Twenty strips lying along the warp and 20 lying along the filling were cut 1¼ inches wide and raveled to one inch. Ten strips on the warp and 10 on the filling from each fabric were exposed to light from a carbon arc lamp in the Atlas Fade-Ometer for 80 hours at 150° F. with humidity controlled. The remaining strips, 10 from the warp and 10 from the filling, were heated in the Precision Scientific Oven for 50 hours at 150° C.

Analyses of color were made on samples of the control fabrics, the fabrics dry-cleaned 30 times, fabrics exposed to light for 80 hours, and fabrics heated for 50 hours. Determinations were made for color attributes according to the Munsell system by the method described by the Bausch and Lomb Optical Company (4). After the sector percentages of neutrals and colors were determined experimentally, the color specifications of hue, saturation (chroma), and brilliance (lightness or value) were calculated according to formulas in the catalogue (4). Then these color specifications were reduced to one figure, the index of fading, by Nickerson's formula (5). In this formula $I = (C/5)d2H + 6dL + 3dC$, in which I = chroma (saturation), and d = difference.

The control pieces were used to determine dry and wet breaking strength both on the warp and filling and for abrasion tests. Ten strips on the warp and 10 on the filling were used for the dry breaking strength; and 10 on the warp and 10 on the filling for the wet breaking strength.

The breaking strength and elongation determinations were obtained by the raveled-strip method on a Scott strength tester at standard conditions according to the method outlined by Committee D-13 (1). Since the thread

(Continued on page 291)

[1]Contribution No. 114, Department of Home Economics, Kansas Agricultural Experiment Station.

[2]Contributions by the junior author were based on results reported in Master's thesis: The Color Fastness of Wool and of Rayon Gabardine to Light, Heat, and Dry Cleaning.

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American Association of Textile Chemists and Colorists

JUNE 21, 1943

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Members should notify the **Secretary** immediately of all address changes.

MEETING, SOUTH CENTRAL SECTION

THE April meeting of the South Central Section was held Friday evening, April 30th, 1943 at the Read House in Chattanooga, Tennessee.

Dinner was served at 7:00 P.M. and attended by sixty-one guests and members.

Frank F. Myers was elected vice chairman and W. J. Kelly, Jr., Councilor, to fill the unexpired term of W. J. Harrison.

The program committee conducted a question and answer program. Marvin Moore led the discussion on the "Present Day Hosiery Dyehouse Problems." Jack Anderson led the discussion on other dyehouse problems.

The group as a whole responded and took part in the discussions and later voiced their approval by asking to have other question and answer programs.

The chairman appointed J. A. Crumbley program committee chairman of the next program, and the time of the next meeting will be announced at a later date. The chairman also appointed J. A. Crumbley, W. K. Newman and Homer Whelchel, as a committee to find a suitable subject for the inter-sectional contest paper, which will be read at a Fall meeting of the New York Section.

Respectfully submitted,

HOMER WHELCHEL, *Secretary.*

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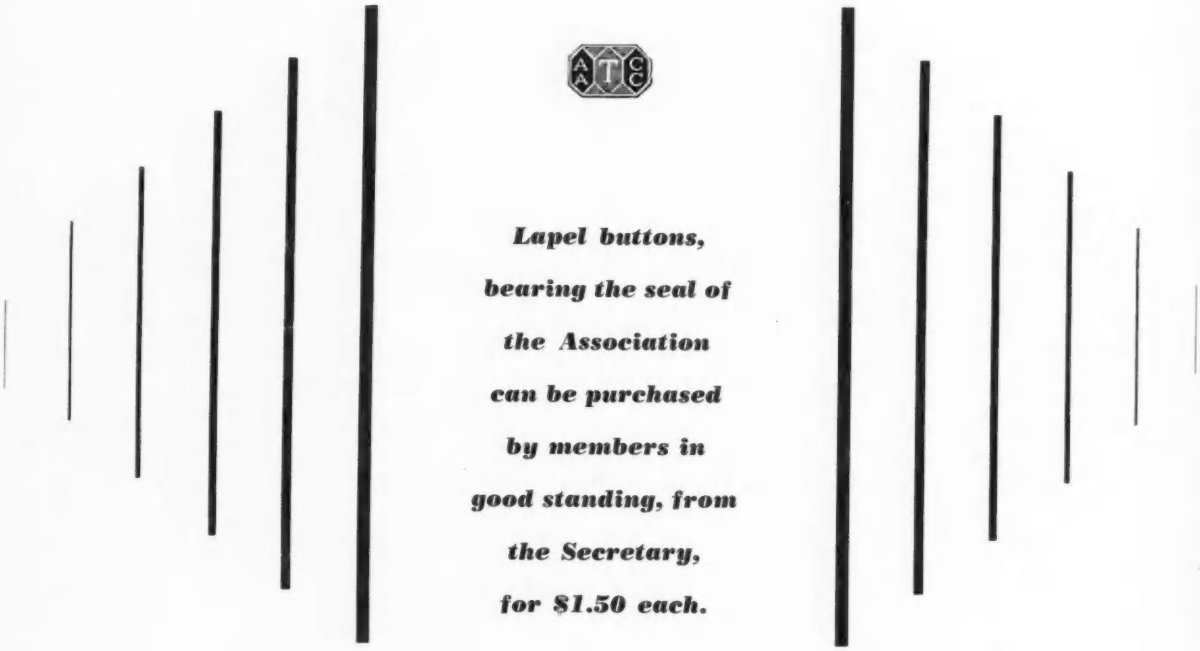
For transfer to Senior membership, Paul J. Luck.

• CALENDAR •
OF COMING EVENTS

Annual Meeting and Dinner, Philadelphia Section, Cedarbrook Country Club, Limekiln Pike above City Line, Mt. Airy, Philadelphia, Pa., July 9, 1943



Lapel buttons, bearing the seal of the Association can be purchased by members in good standing, from the Secretary, for $1.50 each.

MICROSCOPICAL OBSERVATIONS OF WOOL DYEING

Part III—Physical Factors Affecting Color Value

G. L. ROYER, H. E. MILLSON, and E. I. STEARNS

Calco Chemical Division, American Cyanamid Company
Bound Brook, New Jersey

THE amount of dye exhausted from a dye bath does not represent the final color value that is obtained on the dyed goods. The color value is influenced by the distribution and location of the dye in the fabric, thread and individual fiber. In our previous microscopical studies of wool dyeing, which have been published[1, 2], it was shown that the distribution of the dye from fiber to fiber is an important factor relative to the shade and color strength that is obtained and also relative to certain fastness properties. In this paper, some of these physical phenomena will be discussed in regard to their relation to previous observations.

FIBER UNLEVELNESS BY BLENDING

Poor fiber levelness, that is, poor distribution of dye from fiber to fiber, was shown to give low color value and when the same amount of dye was properly distributed the color value increased[2]. It seemed desirable to demonstrate this in another way. Therefore, experiments were made by blending dyed wool, which was completely fiber level, with undyed wool. For the dyed wool with good fiber levelness, various percentage dyeings of Calcocid Blue Black Ex. Conc. (C.I. 246) were made on alcoholic potash treated wool[3] using a bath ratio of 80:1 and dyeing at the boil for 90 minutes with 8 per cent Glauber's salt and 6 per cent of 28 per cent acetic acid. The alcoholic potash treatment makes wool dye with good fiber levelness as can be seen by comparing Fig. 1 with Fig. 2. Fig. 1 shows an untreated high grade Australian wool dyed with a dyestuff which shows poor fiber levelness. When this same wool is given the alcoholic potash treatment and dyed with the same dyestuff under the same conditions, good fiber levelness is obtained as shown in Fig. 2. The alcoholic potash solution used for the treatment contains about 5 per cent of water and this small quantity possibly limits the amount of reaction of the caustic with the wool. Probably the reaction takes place only in so far as the water diffuses into the outer part of the fiber and so the inner part of the wool fiber may remain unchanged. As discussed in the previous papers, the outer surface of the wool fiber seems to be a controlling factor in the diffusion of the dye into the fiber and this treatment apparently changes the surface of the fiber so that the diffusion through this layer is similar for all types of fibers. The alkali potash treatment has been used for making wool non-felting and apparently this is accomplished by a change in the surface of the wool fibers.

Dyeings were made on alkali-treated wool at the following percentages: 6 per cent dye (100 per cent standard), 4.8 per cent (80 per cent), 3.6 per cent (60 per cent), and 2.4 per cent (40 per cent). Measurements on all the exhausts showed greater than 99 per cent exhaustion with all dyeings and since this is within the experimental error of 100 per cent exhaustion, it can therefore be assumed that the values given above represent a complete exhaustion of the dye present. Cross-sections showed good fiber levelness comparable to that shown in Fig. 3 which is the 6 per cent dyeing. Blends of the 6 per cent dyeing with white wool were made by carding to give the same concentration of dye per unit weight of wool as is present in each of the other three unblended dyeings. The color value and shade of these blends were compared by visual and spectrophotometric methods with the completely dyed unblended samples. Table I gives a summary of the results and Fig. 4 shows a plot of the brightness (Y) values as determined by the spectrophotometer plotted against the actual amount of dye expressed in per cent for both the dyeings and the blends.

TABLE I

		COLOR STRENGTH Visual Estimate	*Colorimetric*
100% dyeing	6% dye		100
80% blend	4 parts 6% shade 1 part undyed	Definitely weaker & redder than 80% dyeing.	15
dyeing	4.8% dye		80
60% blend	3 parts 6% shade 2 parts undyed	Definitely weaker & redder than 60% dyeing.	7
dyeing	3.6% dye		60
40% blend	2 parts 6% shade 3 parts undyed	Definitely weaker & redder than 40% dyeing.	4
dyeing	2.4% dye		40

The visual estimates, which are only approximate, are the opinions of eight colorists who compared the blends with the dyed samples, using the latter as standards. The blends were different in appearance due to the presence of the undyed fibers and the change in shade, but they were compared for their over-all color value, through previous experience in color matching.

The usual way in which a dyer describes a change in color such as is found by mixing white fibers in a sample of dyed wool slubbing is to state that the color has lost depth or body. If the dyer goes further and attempts to give a quantitative estimate of the color change, he com-

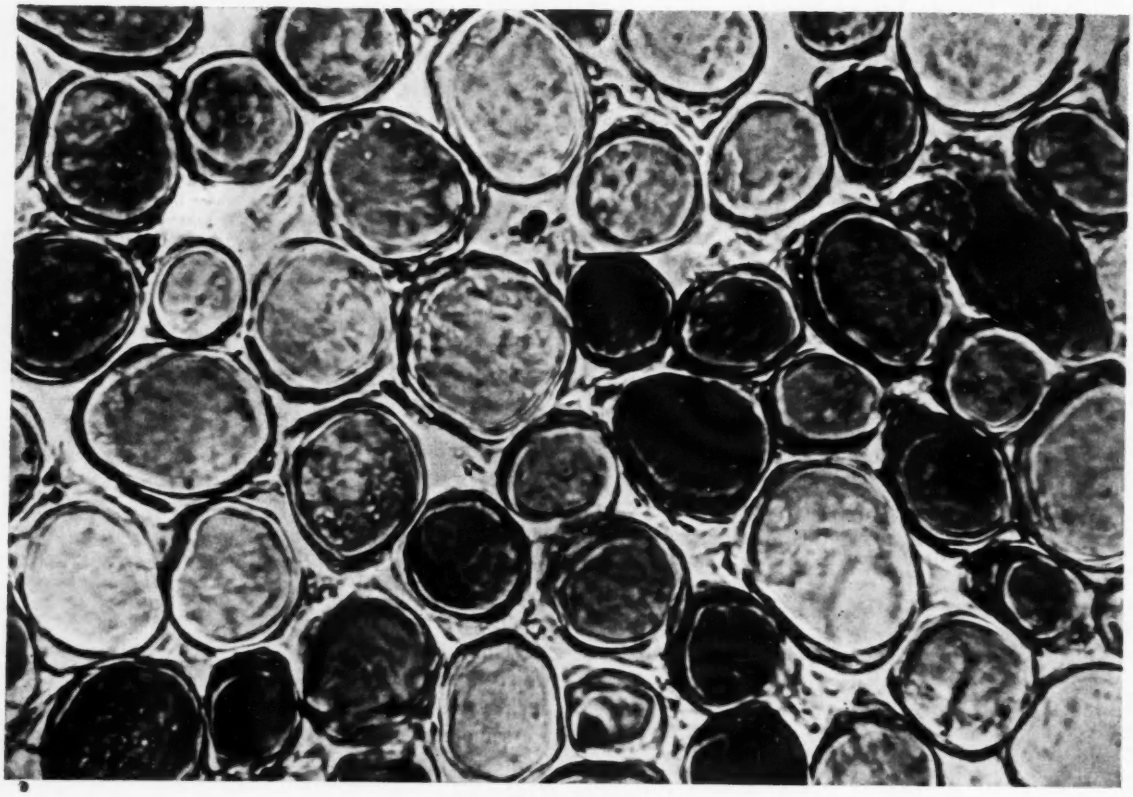


FIGURE 1

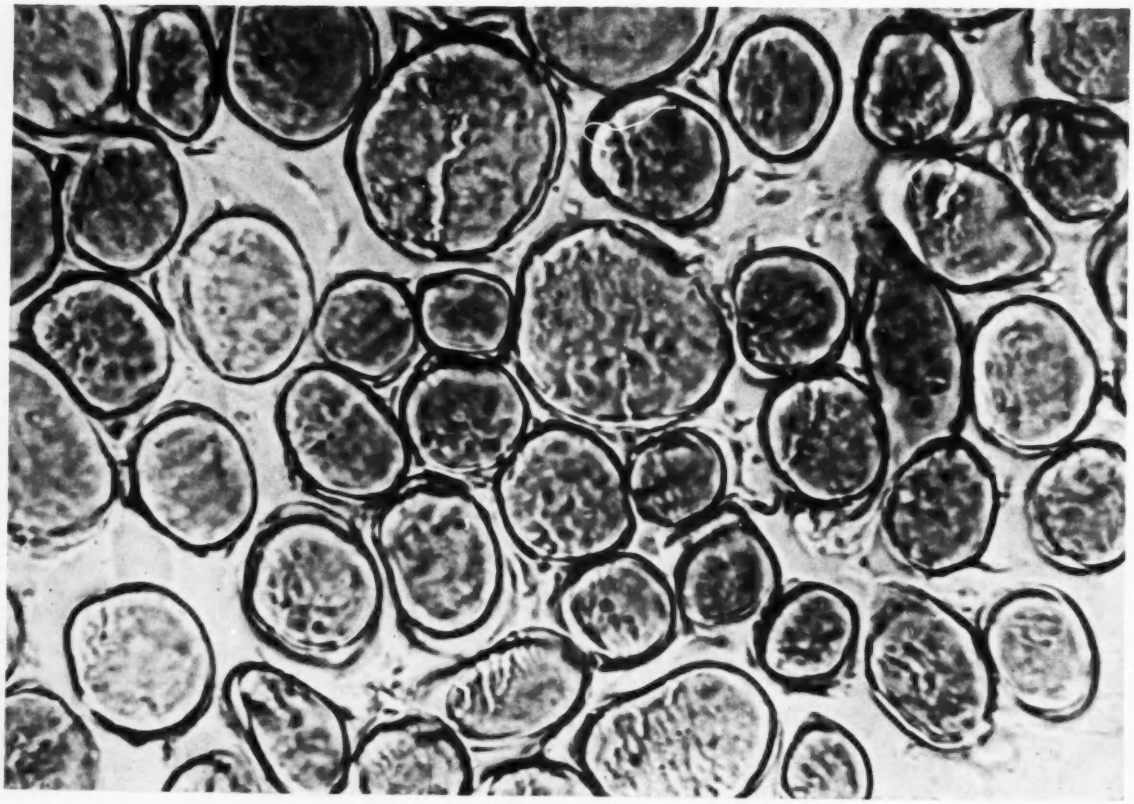


FIGURE 2

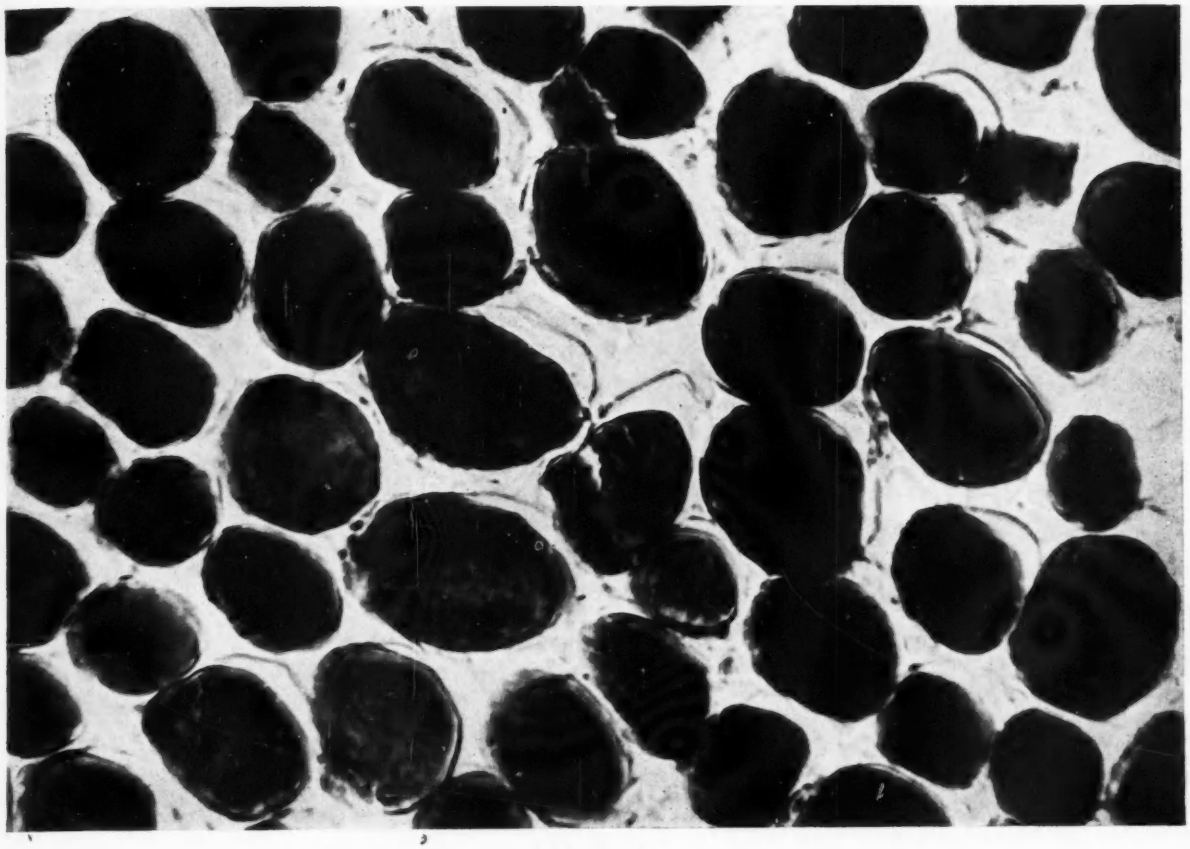
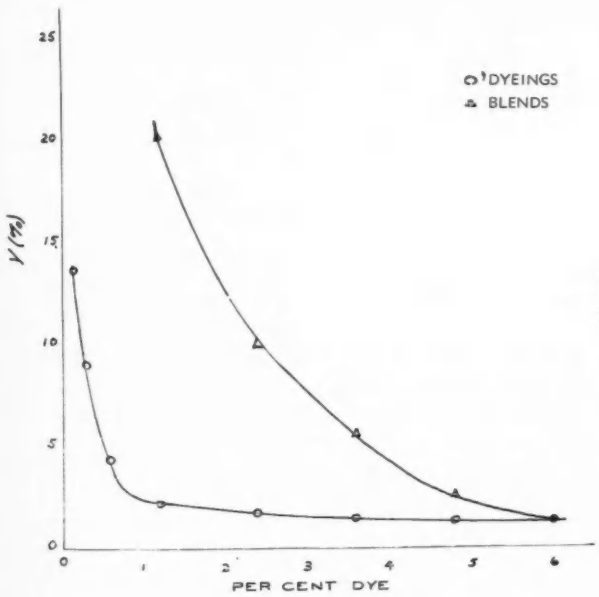
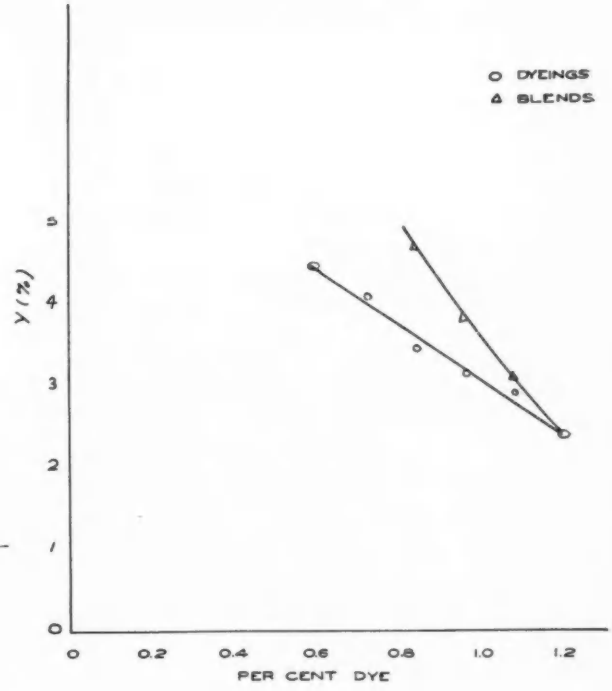


FIGURE 3



ABOVE—FIGURE 4



RIGHT—FIGURE 5

pares it to the loss in depth or body which results from a decrease in the amount of dye used. Thus, when a sample is evaluated by the dyer as being 20 per cent weaker, he means that the loss in total depth is approximately equal to the loss in depth that would result from using only 80 per cent of the dye in the original formulation.

Because the shade changes in a different way when the dye usage is decreased than when white wool is blended in, such evaluations are only approximate. Even if a neutral gray were used so that the same shade would result by either method of reduction in total dye present, a further difficulty would be encountered because of the tendency of the dyer to unconsciously ignore the white wool and evaluate only the colored wool in a coarse mixture.

One colorimetric term used by physicists to express the results of spectrophotometric evaluations is brightness, designated by "Y." It is a term related to the total amount of light reflected from a sample and takes into consideration the sensitivity of the eye and the quality of daylight. The exact definition of this term can be found in an article by D. B. Judd[4]. The smaller the value for "Y," the greater the color strength. This term "Y" must not be confused with the dyer's term "brightness" which refers to the clarity of the shade.

In order to interpret the spectrophotometric data in terms used by dyers, the following procedure was followed. The colorimetric brightness "Y," which is known to vary with concentration of dye, was measured for the series of level dyed wools. These data are plotted as circles in Figures 4 and 5, and represent a standard curve. The colorimetric brightness of the blends was then calculated from spectrophotometric data and an interpolation made on the standard curve to determine what strength unblended dyeing would have an equivalent brightness. This interpolated value is reported in Tables I and II as the color strength determined colorimetrically from brightness measurements.

The strength determined in this way will disagree with the dyer's strength because other colorimetric factors of the physicist, namely, "dominant wave length" and "purity," have been ignored. On the other hand, different dyers will arrive at different strength values, depending on the importance they attach to the various colorimetric factors. Thus, there is no single, true answer, and it is usually not worth while to determine the exact correlation between spectrophotometric and visual data for the readings made by an individual dye tester.

It can be seen from Table I and Fig. 4 that the best color value is obtained for the same amount of dye present when it is well distributed in completely dyed samples. A 10 per cent reduction with white wool makes a much greater change in shade and color strength than a 10 per cent reduction in the amount of dye used. These experiments confirm the observations made from previous microscopical examinations and show the desirability of obtaining dyeings of good fiber levelness and solidity of shade in contrast to ones with poor fiber levelness, having a skittery appearance.

It was somewhat difficult to make comparisons of these blends with the unblended dyeings because of changes in the shade of the blended sample and the presence of the undyed wool which gave a gray appearance. This was also noticed in our previous[2] estimations of the color strength of unlevel fiber dyeings. Unlevel fiber dyeings obtained by dyeing at low temperatures could not be matched in shade by dyeings at reduced concentrations of level fiber dyeings obtained at the boil without the addition of a second dye. In the dyeings and blends described in Table I, no exact visual color strength could be given because when attempts were made to dye shades weak enough, they became very blue and this blueness added another factor, namely, that of an extreme difference in shade. Therefore, as a further experiment, another series was made to cover a shorter range of concentrations which resulted in less shade change and more suitable for visual matching. The percentage of 1.2 per cent was chosen for the 100 per cent of this series. Table II gives the values obtained for both the blends and dyeings and Fig. 5 shows the plot for the brightness (Y) against the grams of color present per hundred grams of wool. These results also confirm the fact that good fiber levelness gives the best color value and produces the fully developed shade of the dye.

TABLE II

		COLOR STRENGTH Visual Estimate	*Colorimetric*
100% dyeing	1.2% dye		100
90% blend	9 parts 1.2% shade 1 part undyed	About 80% & redder.	83
dyeing	1.08% dye		90
80% blend	8 parts 1.2% shade 2 parts undyed	About 70% & redder.	65
dyeing	0.96% dye		80
70% blend	7 parts 1.2% shade 3 parts undyed	About 60% & redder.	44
dyeing	0.84% dye		70

DYE DISTRIBUTION WITHIN SINGLE FIBERS

In our microscopical investigations of fiber levelness, we have noticed uneven distribution within the same single fiber. Many times, if dyeing is stopped in the early stages, or if the dye diffuses slowly, the dye will not have diffused throughout the fiber and "ring dyeing" results. Other times one part of a fiber will be dyed while another portion contains no dye at all.

An example of the effect of dye distribution within the individual fibers upon the visual reflectance is shown in redyeing. Proof that light is reflected from the body of the fiber may be obtained by redyeing medium to heavy colored wool yarns into black. When Fast Acid Black B (C.I. 307) is used for redyeing, it generally produces ring dyeing and partial penetration. This makes it possible to have the outer portion of the fiber dyed black while the inner part of the fibers retain some of the original shade. Fig. 6 shows a cross section of such a dyeing. The outer ring is dyed black and the clear portion in the center is dyed red. This photomicrograph was taken with a red filter so that the red would appear clear. Blacks produced

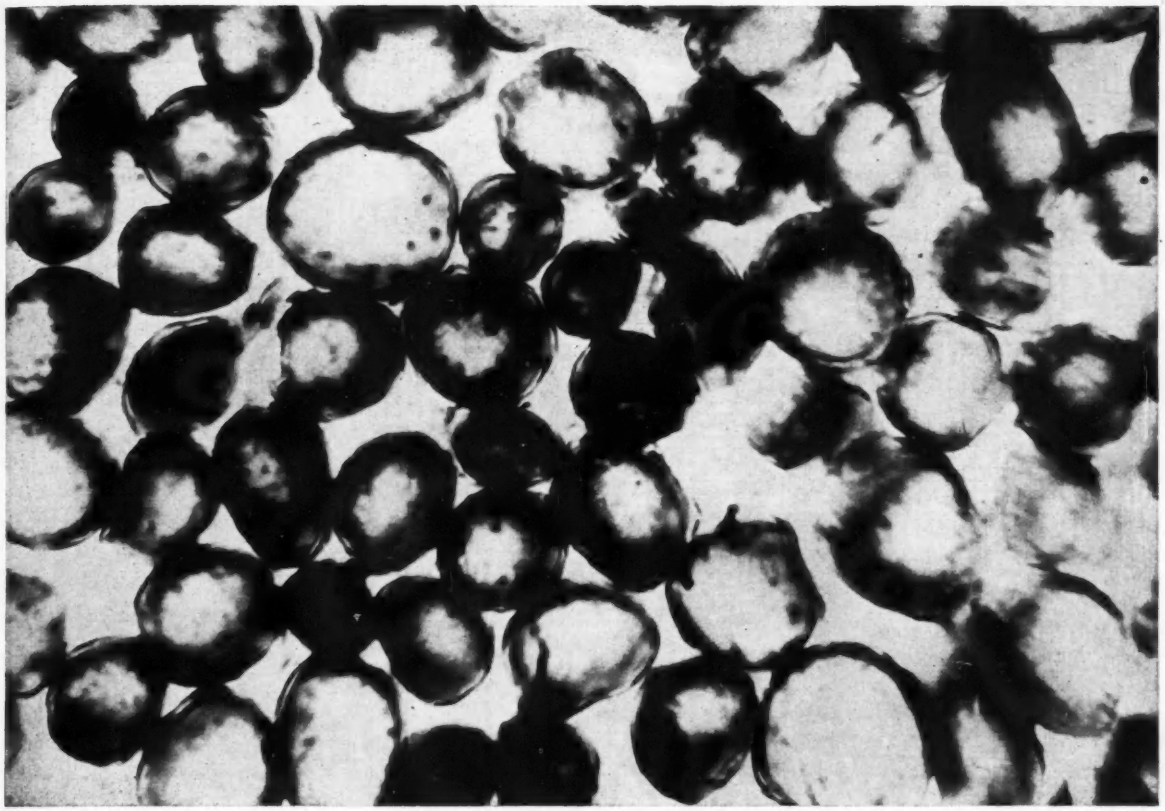


FIGURE 6

in this way appear to be a good shade of black when examined by looking down on them, but the overtone is influenced by the color of the wool before dyeing. A scarlet redyed black will have a reddish overtone while a green or yellow redyed black will have a greenish or yellowish overtone. This is caused by optical relationships within the fiber which give different reflectances, depending on the location of the eye. A similar phenomenon occurs in regular dyeing if dyes of different diffusion rates are used. In this case, the dyes are not equally distributed within the fibers and cause results comparable to those in redyeing.

FIBER SIZE STUDIES

In our early studies of fiber levelness, it was thought that the fiber unlevelness might be caused by the variation of fiber sizes which are present in most wool blends. However, no correlation could be found between the heavily and lightly dyed fibers and the fiber diameter when cross sections were examined. It is known that wools of different fiber diameters dye at different rates and that the color values obtained are different. To show the correlation, samples of 64's and 36's were obtained[5] and 5-gram samples of each were dyed with 0.5 per cent of Calcocid Blue Black Ex. Conc. (C.I. 246) at the boil in a pH 5 buffered bath under the same dyeing conditions. The dye exhaust rate curves are shown in Fig. 7. It can be seen that the fine diameter fiber wool, the 64's, dyed much faster and came to equilibrium exhaustion sooner than the 36's. At the end of the dyeing, the 64's had exhausted about 97 per cent of the dye, while the 36's had exhausted 80 per cent. An examination of the wools shows the 36's to be much heavier in color value than the 64's even though it contains 17 per cent less dye. The spectrophotometric method shows the 64's to be about 60 per cent the color strength of the 36's. That is, on the reflectance basis, it would be necessary to use 67 per cent more dye to get the same depth of color on the fine wool. A microscopical examination of the cross sections shows both samples to be level fiber dyed since a level fiber dyeing dye was chosen so the fiber levelness phenomena would not be a factor in this experiment. Since both samples of wool contained within 20 per cent of the same amount of dye per gram of wool, the fibers in cross section, which are all the same thickness, appear to be about the same shade and color strength even though they show different color strengths on examination in skein or slub form.

To show that fiber unlevelness and rate of dyeing were not factors, the same experiments were repeated on the same wools after they had been given the alcoholic potash treatment described in the first part of this paper. The dyeing rate was increased to such an extent that there appeared to be no difference in rate and both samples showed the same equilibrium exhaustion value of about 100 per cent in less than 5 minutes. The spectrophotometric esti-

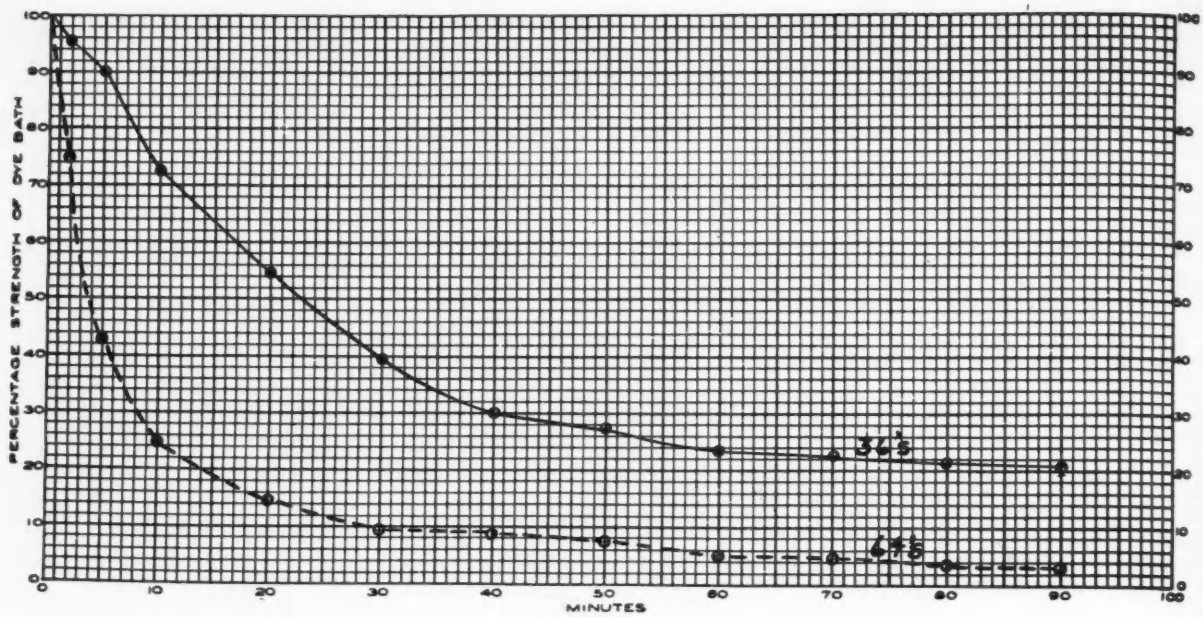


FIGURE 7

mated color strength of the 64's was about 50 per cent when the 36's were taken as 100 per cent. This again confirms the fact that even with the same quantity of dye per gram of wool, the finer fiber diameter wool will be lower in visual color value. To give the same visual appearance, more dye must be applied to fine wool to match the color strength of an equivalent weight of coarse wool.

Observation of the color strength of the two wools themselves during the dyeing shows that at the beginning of the dyeing the fine wool 64's are stronger in color value than the coarse 36's because of the great difference in the dyeing rate. However, as dyeing proceeds, the coarse wool gains in color strength and at the end of the dyeing will be almost twice as heavy in color for equal quantity of dye exhausted. The dyeing is much faster for the fine wool because of the greater surface area which is exposed to the dye and so it quickly diffuses into the wool proper and the equilibrium between the fiber and the dye is rapidly attained. In the case of the coarse wool, the dye must diffuse through a greater distance before equilibrium is reached. The same quantity per gram of wool is finally taken up by both, but the difference in fiber diameter controls the time for diffusion and therefore for uniform distribution of dye within the fibers.

This effect of fiber size on color value may be explained by a study of the relation of surface area to the phenomena of reflectance. In general, the light reflected from fibers may be separated into two types. One being reflected only from the surface and known as surface reflectance and the other being scattered after penetrating into the body of the fiber and known as the body color. The surface reflectance is similar to that from a mirror and so this light is reflected unchanged and is independent of the dyed color of the actual fiber itself. The light reflected from within the fiber contributes the color resulting from the dye. Thus, an increase of the surface reflectance will reduce the color strength due to the larger ratio of unchanged reflected light coming from the surface as compared to that coming from within the fiber. The 64's wool has much greater surface area than the 36's and the reflectance of light from this surface gives the fine wool the low color strength.

CONCLUSIONS

In this paper, an attempt has been made to show by blending that fiber unlevelness gives poor color strength and a different shade. This confirms earlier publications in which this conclusion was made from microscopical examinations. The effect of fiber diameter upon color strength has been shown using 64's and 36's wools. These show that for the same amount of dye, the greatest color value is obtained on the coarser wool, i.e., more dye must be used in dyeing fine wool in order to match the same shade on coarse wool. A brief discussion of the optical phenomena entering into the color value obtained on wool has been given.

The authors wish to thank C. L. Zimmerman for making the dyeings and other co-workers for the help received in obtaining the necessary data and for suggestions in making this paper possible.

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WOOL AND RAYON GABARDINES

(Continued from page 280)

count of the samples for breaking strength varied as a result of shrinkage and abrasion, all the results of breaking strength for each material were corrected to thread count of the dry control as follows: The breaking strength was multiplied by the thread count of the control and the product was divided by the thread count of the sample broken.

The relative wearing qualities of the fabrics were obtained by comparing the breaking strength of the original fabrics with pieces that had been abraded by a M.I.T. model abrasion tester. Strips 6 x 24 inches were abraded 300 times using a one-inch roller and 2/0 emery cloth for the abradant (6). Strips for warp and filling breaking strength of the controls were tested for abrasion.

Shrinkage was determined by comparison of measurements made before and after dry cleaning. Squares 10 inches in dimensions were marked off on the fabric with white cotton thread. These squares were measured after 1, 5, 10, 15, 20, 25, and 30 dry cleanings.

The dynamic properties of the rayon and wool yarns were determined by taking load-elongation curves with a Saxl yarn tester (7, 8). This machine was hand operated and uniform loading was made possible with a slide weight on a balance arm. The elongation of the yarn was read in five times magnification on a directly calibrated scale. Before taking the load-elongation curves most of the waviness of the yarns was removed by allowing them to hang in a conditioning room several days before testing. Readings were taken in a conditioned atmosphere on a five-cm. length of the yarn. One or two minutes as determined by a stop watch were allowed between readings for the curves. Load-elongation curves were taken of both warp and filling yarns from the rayon and wool fabrics of the controls and after 30 dry cleanings.

The thermal transmission was determined with the Cenco Fitch thermal conductivity apparatus (9) as described by Schwarz (10, 11). Because the fabrics were firm and closely woven no attempt was made to measure the thermal transmission with no or little pressure. The pressure of the calorimeter filled with water within 3 cm. of the rim and the immersion heater was exerted on the fabrics when the determinations were made. The pressure was 1.9 lb. per sq. in. The thickness of the fabrics was measured at this same pressure with a thickness gauge. The galvanometer readings were taken every minute for a period of 10 minutes. The galvanometer deflections were plotted as ordinates and time in seconds as abscissas on semi-logarithmic paper. The slope of the straight line as given by Fitch (9) is:

$$S = -\frac{kA}{2.303cML}$$

in which k is the thermal conductivity in calories transmitted through one cu. cm. in one sec. at one degree centigrade difference in temperature, A is the area of the lower block, M its mass, c its specific heat, and L the thickness of the specimen under test. For the apparatus used, the diameter of the lower block, is 4.5 cm.; M is 340 g.; and c is .093. The equation then becomes:

$$S = -.218\frac{k}{L}$$

in which:

$$S = -\frac{1}{\text{time in sec.}}.$$

The time in seconds corresponds to a change of one cycle in the ordinate. The thermal conductivity was determined for the rayon and wool gabardines before and after dry cleaning.

RESULTS

Finishes and Identification of Dyes

A small amount of finish was found on both groups. The rayons had less than one per cent and the wool fabrics not more than two. None possessed any resin finishes. The percentages of the finishes are given in Table I.

The results on the identification of the dyes are shown in Table I. None of these were vat dyes which are unusually colorfast. Most of the wools were dyed with acid or acid mordant dye. The rayon mixtures all were dyed with substantive dyes which would dye the viscose and also with acid, basic, basic mordant or developed dyes which would dye the acetate.

Statistical Analysis of Data on Fading

The data on color fastness were evaluated by the analysis of variance (12, 13). Using the indices of fading (I) as obtained from Nickerson's formula it was found that variance for treatments (control, 30x dry-cleaned, 80 hrs. light exposure, 50 hrs. heat exposure) plotted against the means of the indices for these treatments gave a straight line. This correlation showed that the indices did not form a normal population. A transformation was made using $I' = \sqrt{I + .5}$. The transformed indices (I') were analyzed. Table II gives the results of the analysis on color fastness.

In obtaining the F-function for the three sources of variation in Table II, the mean square of fabrics, of treatments, and of "colors within fabrics" would usually be compared with the mean square of the interaction term, "fabrics x treatments." However, in this study there was no interaction of "fabrics x treatments" and the sum of squares of "fabrics x treatments" was pooled with the sum of squares of the remainder to give a new mean square which was used as the error term. As a check against this method the mean square of "colors within fabrics" was then used as the error term for the first two sources of variation. Neither error term showed a significant difference between the two groups of fabrics. The F-test showed that the observed differences in fading among the different treatments would be produced by sampling varia-

TABLE I
Physical Characteristics of Rayon and Wool Gabardines; All Fabrics Were Right Twills Except I and Had Z Direction of Twist

Fabrics	*Width (in.)*	*Warp*	*Filling*	*Thickness (in.)*	*Wt. per sq. yd. (oz. dry wt.)*	*Crimp per cent* *Warp*	*Filling*	*Yarn counts (Typp, dry wt.)* *Warp*	*Filling*	*Twist per inch* *Warp*	*Filling*	*Weave*	*Fiber content (per cent)* *Wool*	*Acetate*	*Viscose*	*Finish (per cent)*	*Dyes*
Rayon																	
A Light red	39	105.2	57.4	.0187	5.4	12.4	11.7	19.6	18.9	25.2±.4	24.7±.2	2/1			39.0	61.0	.6	Acid mordant
B Dark red	39	105.4	57.0	.0188	5.6	10.6	13.2	18.6	19.2	24.8±.4	25.6±.4	2/1			39.4	60.6	.6	Substantive
C Light green	39	105.2	57.4	.0197	5.7	17.8	16.0	19.4	20.5	25.0±.3	25.6±.3	2/1			39.4	60.6	.5	Acid mordant
D Dark green	39	104.2	58.8	.0194	5.6	14.4	7.4	18.6	18.0	25.0±.3	25.5±.5	2/1			39.3	60.7	.4	Acid
E Light blue	39	104.4	57.2	.0189	5.4	23.2	20.3	20.7	20.9	25.4±.5	25.7±.3	2/1			39.4	60.6	.9	Acid mordant
F Dark blue	39	104.8	58.0	.0198	5.7	13.7	9.7	18.7	18.1	24.9±.3	25.2±.3	2/1			39.4	60.6	.6	Acid
G Light brown	39	103.6	56.0	.0190	5.4	16.9	13.8	19.3	19.9	25.4±.4	24.5±.3	2/1			38.9	61.1	.6	Acid mordant
H Dark brown	39	104.6	59.0	.0193	5.5	11.0	14.4	18.7	19.5	25.4±.4	24.7±.3	2/1			39.0	61.0	.6	Acid mordant
I White	38.5	72.4	59.0	.0156	4.1	19.6	23.6	21.2	22.5	15.2±.7	14.7±.6	1/1			50.9	49.1	.8	
Wool																	
J Light red	57	88.2	47.6	.0197	4.6	12.7	14.3	18.2	21.1	15.7±1.7	15.6±1.5	2/1	100				2.0	Substantive, acid
K Dark red	59	126.6	89.6	.0206	6.2	19.9	14.1	21.6	26.8	21.0±1.1	19.9±1.4	$\frac{2}{2}\frac{1}{1}$	100				1.0	Substantive, acid, basic
L Light green	55	125.4	95.6	.0234	6.6	26.8	12.7	21.4	25.4	22.0±1.7	17.4±0.8	$\frac{2}{2}\frac{1}{1}$	100				.9	Substantive, acid, basic
M Dark green	56.5	90.8	49.2	.0186	4.6	7.6	6.1	17.7	18.9	14.7±1.6	16.5±1.5	2/1	100				2.0	Substantive, acid, developed
N Light blue	57	89.4	51.2	.0191	4.6	9.6	6.9	18.3	20.8	18.6±0.9	16.4±1.0	2/1	100				1.0	Substantive, acid, basic, basic mordant
O Dark blue	54.5	126.4	90.4	.0221	6.3	17.0	8.1	20.5	24.4	23.6±1.0	18.8±0.6	$\frac{2}{2}\frac{1}{1}$	100				.8	Substantive, acid, basic mordant, developed
P Light brown	57	88.0	50.0	.0202	4.6	21.6	7.8	20.0	20.1	18.5±2.0	15.6±1.6	2/1	100				1.8	Substantive, acid, basic
Q Dark brown	55.5	122.8	88.8	.0209	5.9	14.7	11.6	22.2	26.4	27.4±1.0	20.4±0.7	$\frac{2}{2}\frac{1}{1}$	100				1.6	Substantive, acid, basic developed
R White	56.5	90.2	50.8	.0202	4.8	10.5	15.9	17.4	20.2	14.4±2.4	18.8±1.8	2/1	100				1.2	

TABLE II
Analysis of Variance of Fading for Rayon and Wool Gabardines.

Source of variation	*Degrees of freedom*	*Mean square*	*F (error term of remainder)*	*F (error term of colors within fabrics)*
Fabrics (rayon, wool)	1	1.31971	1.96	
Treatments (30 x dry-cleaned, 80 hrs. light, 50 hrs. heat)	2	8.56000	12.74**	4.77*
Colors within fabrics	14	1.79779	2.67*	
Remainder	30	.67232		
Total	47			

*Significant (variation exceeded 5 per cent level)
**Very highly significant (variation exceeded 0.1 per cent level).

tion alone less than one time in 1000 samples with the first error term or less than once in 20 samples with the second error term; hence it was assumed that the treatments did have different effects upon fading. The probability that the difference in treatment was due to sampling variation was less then .001 for the first error term and less than .05 for the second. Likewise the colors within fabrics in both the wool and rayon showed a significant difference in indices of fading. Thus, there was more variation between the colors within the fabrics than there was between the two groups of fabrics.

The t-test was used on the arithmetic means in order to evaluate specific differences between treatments. Dry cleaning had little effect on the color in both groups; ten specimens did not fade at all and the others, with the exception of the whites, faded only slightly. There was not a significant difference between fading due to light and heat, but both produced considerably more fading than dry cleaning.

For the white samples it was advisable to make a separate comparison, because in both the wool and rayon groups the white fabrics did not follow the trend in color changes of the dyed fabrics. The white rayon showed no change of color on exposure to light, but the wool turned yellow. On heating both turned, but the wool showed the greater color change. After dry cleaning both wool and rayon fabrics turned grey.

Statistical Analysis of Data on Breaking Strength and Elongation

Tables III and IV give the breaking strength and elongation for the controls and after 30 dry cleanings of the rayon and wool fabrics. Breaking strength and elongation data were also obtained for all fabrics on the warp after 10 and 20 dry cleanings. These data were analyzed by the analysis of variance. Table V gives the results of the analysis of data for breaking strength and elongation on the controls, both wet and dry, after abrasion, and after exposure to light and heat.

The breaking strength of the rayon was significantly greater than the wool over all treatments in both warp and filling, and the interactions of fabrics x treatments and treatments x warp vs. filling were very highly significant. The t-test was used to test the differences

TABLE III

Dry and Wet Breaking Strength in Pounds of Controls After Abrasion, Exposure to Light and Heat, and After 30 Dry Cleanings for Rayon and Wool Gabardines.

Fabrics	*Dry*		*Wet*		*Abraded*		80 *hrs. light exposure*		50 *hrs. heat exposure*		30 *x dry-cleaned*
	Warp	*Filling*	*Warp*	*Filling*	*Warp*	*Filling*	*Warp*	*Filling*	*Warp*	*Filling*	*Warp*
Rayon											
A Light red	62.5	35.8	29.5	18.8	12.0	34.8	55.8	32.7	58.2	31.2	55.1
B Dark red	65.5	35.6	31.0	19.0	11.6	36.1	43.7	24.8	59.5	28.7	54.2
C Light green	66.0	36.1	28.7	18.1	6.9	35.7	58.1	34.2	59.2	33.5	58.7
D Dark green	61.0	37.5	29.1	19.8	14.7	35.7	57.4	30.7	56.9	29.7	57.2
E Light blue	63.8	37.9	28.4	20.2	11.1	37.8	59.5	33.1	58.1	32.0	56.1
F Dark blue	62.6	36.8	28.9	20.2	13.6	39.2	58.7	30.7	57.8	34.1	54.5
G Light brown	61.1	35.4	30.9	19.1	14.9	33.1	54.5	33.2	59.3	31.7	54.6
H Dark brown	63.6	37.3	29.0	21.0	13.5	37.2	53.6	23.7	59.3	33.3	56.6
Ave. of rayon	63.3	36.6	29.4	19.5	12.3	36.2	55.2	30.4	58.5	31.8	55.9
Wool											
J Light red	38.1	17.0	25.3	12.3	17.0	17.2	26.4	11.9	37.7	15.7	36.4
K Dark red	48.6	25.5	28.9	15.4	25.9	27.3	25.3	17.3	47.6	23.8	45.9
L Light green	42.8	27.5	19.2	14.6	22.9	28.2	28.5	19.0	41.5	25.1	40.0
M Dark green	37.9	15.2	25.1	10.9	24.7	17.8	21.6	10.7	37.0	14.9	36.7
N Light blue	35.9	18.1	21.1	9.8	23.8	15.2	17.2	10.0	34.8	16.1	34.4
O Dark blue	48.4	28.4	31.4	18.9	20.9	29.4	19.8	16.4	49.7	26.2	47.0
P Light brown	35.4	17.4	25.6	10.7	12.9	16.6	14.3	10.3	37.1	16.2	37.5
Q Dark brown	40.1	23.3	19.0	10.0	16.1	24.5	24.2	15.8	40.3	21.7	36.6
Ave. of wool	40.9	21.6	24.4	12.8	20.5	22.0	22.2	13.9	40.7	20.0	39.3

TABLE IV

Dry and Wet Elongation in Percent of Controls After Abrasion, Exposure to Light and Heat, and After 30 Dry Cleanings for Rayon and Wool Gabardines.

Fabrics	*Dry*		*Wet*		*Abraded*		80 *hrs. light exposure*		50 *hrs. heat exposure*		30 *x dry-cleaned*
	Warp	*Filling*	*Warp*	*Filling*	*Warp*	*Filling*	*Warp*	*Filling*	*Warp*	*Filling*	*Warp*
Rayon											
A Light red	.90	.59	.76	.64	.31	.58	.74	.52	.79	.56	.84
B Dark red	.91	.58	.80	.66	.30	.58	.61	.37	.77	.48	.85
C Light green	.94	.64	.79	.65	.23	.62	.79	.54	.84	.54	.85
D Dark green	.90	.63	.96	.63	.36	.61	.77	.50	.81	.53	.87
E Light blue	.87	.61	.80	.65	.24	.62	.76	.54	.77	.54	.86
F Dark blue	.92	.60	.94	.63	.37	.60	.78	.48	.85	.54	.84
G Light brown	.89	.63	.97	.62	.32	.58	.80	.51	.78	.55	.83
H Dark brown	.85	.63	.76	.64	.31	.62	.75	.49	.75	.54	.79
Ave. of rayon	.90	.61	.85	.64	.30	.60	.75	.49	.80	.54	.84
Wool											
J Light red	1.03	.64	2.04	1.56	.34	.68	.31	.27	.77	.51	1.07
K Dark red	1.40	.65	2.36	1.55	.55	.56	.37	.32	1.02	.48	1.40
L Light green	1.26	.54	2.05	1.51	.54	.56	.49	.24	.96	.44	1.10
M Dark green	.93	.58	1.86	1.56	.23	.68	.25	.27	.71	.48	.92
N Light blue	1.07	.61	1.89	1.49	.44	.55	.24	.21	.79	.50	1.07
O Dark blue	1.50	.67	2.54	1.59	.50	.76	.32	.27	1.19	.56	1.56
P Light brown	1.23	.76	2.00	1.58	.34	.65	.16	.27	.82	.61	1.16
Q Dark brown	.90	.36	2.36	1.46	.40	.41	.34	.23	.78	.33	.80
Ave. of wool	1.16	.60	2.14	1.54	.42	.61	.31	.26	.88	.49	1.14

TABLE V

Analysis of Variance of Breaking Strength and Elongation of the Controls for Rayon and Wool Gabardines.

Source of variation	*Degrees of freedom*	*Mean square*	
		Breaking strength	*Elongation*
Fabrics (rayon, wool)	1	7191.73*	1.48225
Treatments (dry, wet, abraded, light, heat)	4	2349.08	3.69674
Warp vs. filling	1	6023.33	1.81050
Fabrics x treatments	4	648.43**	2.28905**
Fabrics x warp vs. filling	1	13.46	.19881**
Treatments x warp vs. filling	4	1783.50**	.60910**
Remainder	144	26.13	.01330
Total	159	....	....

*Significant (variation exceeded 5 per cent level)
**Very highly significant (variation exceeded 0.1 per cent level).

between specific fabrics, treatments, warp and filling. In the dry control, rayon was stronger than the wool. The probability that the observed difference would be produced by sampling variation alone was less than .001. In case of the wet breaking strength the probability was less than .01 and of the abraded much greater than .05. Thus, moisture decreased the breaking strength of wool less than that of rayon, and the wool gabardines were more resistant to abrasion. Likewise it was seen that on exposure to heat the breaking strength of neither was significantly decreased; but light decreased the strength of wool more than that of rayon. In both the wool and rayon the warp breaking strength was greater than that of the filling except after abrasion and then the filling was greater than the warp.

There were no significant differences of elongation between the two groups of fabrics, over all treatments, and warp and filling. All three interactions—fabrics x treatments, fabrics x warp vs. filling, treatments x warp vs. filling—were very highly significant. The elongation of the wool was greater than of the rayon for the dry and wet. On exposure to light the elongation of the rayon was greater than the wool. There were no significant differences in elongation of the wool and rayon after abrasion and on exposure to heat. Thus, moisture increased the elongation of wool but not of rayon; abrasion, light and heat decreased the elongation of rayon less than that of wool. Over both groups of fabrics and all treatments the elongation of the warp was greater than of the filling except after abrasion and then the elongation of filling was greater.

Effect of Dry Cleaning on Breaking Strength and Elongation

Breaking strength and elongation determinations on the warp were made on the control and after 10, 20 and 30 dry cleanings. These results after 30 dry cleanings are given in Tables III and IV.

The statistical analysis of the data on breaking strength showed a significant decrease in the rayon but not in the wool after 30 dry cleanings. Dry cleaning did not affect the elongation.

Effect of Dry Cleaning on Shrinkage

Shrinkage determinations were made after 1, 5, 10, 15, 20, 25, and 30 dry cleanings. The shrinkage after 1, 10 and 30 dry cleanings is given in Table VI. It was found that the variance of shrinkage for the various dry cleanings (1, 5, 10, 15, 20, 25, and 30) plotted against the means for these dry cleanings gave approximately a straight line. This correlation was broken up by the transformation of $S' = 1/\sqrt{S + 1.5}$ where S is the per cent shrinkage and S′ is the transformed number. Table VII gives the results of the analysis of variance of the transformed data for shrinkage.

The two groups of fabrics showed no difference in shrinkage as a result of all dry cleanings; the differences in shrinkage between dry cleanings (1, 5, 10, 15, 20, 30) were not important; however, the warp shrank much more than the filling. There were strong interactions in fabrics x dry cleanings and fabrics x warp vs. filling. In the first interaction the t-test showed that the rayon did not increase in shrinkage with successive dry cleanings but the wool did increase. In the second interaction there was not a significant difference in shrinkage in the warp between rayon and wool, but in the filling the wool shrank more than the rayon.

Dynamic Properties of Rayon and Wool Yarns

Figures 1, 2 and 3 show typical load-elongation curves for the rayon and wool yarns. In Figure 1 are shown the dynamic characteristics of the rayon, wool, and cotton. Cotton was studied simply for a comparison. These showed that rayon was definitely different from the wool and

TABLE VI

Shrinkage in Per Cent After One, Ten and 30 Dry Cleanings for Rayon and Wool Gabardines.

Fabrics	*One dry cleaning*		*Ten dry cleaning*		*30 dry cleaning*	
	Warp	*Filling*	*Warp*	*Filling*	*Warp*	*Filling*
Rayon						
A Light red...	2.5	1.5	4.5	2.5	7.0	2.0
B Dark red...	3.0	1.0	4.0	1.0	7.0	0.0
C Light green.	5.0	0.5	4.0	0.0	6.0	0.0
D Dark green.	4.5	1.0	5.5	1.0	6.0	1.0
E Light blue..	3.5	1.0	6.0	1.0	6.0	1.0
F Dark blue..	3.5	1.0	6.0	0.0	7.5	0.5
G Light brown	2.5	1.0	6.0	0.0	7.5	0.5
H Dark brown	3.0	1.0	4.5	0.0	6.0	—1.0*
Wool						
J Light red...	1.5	1.0	4.0	1.0	5.5	3.0
K Dark red...	4.0	0.5	7.0	0.0	10.5	1.0
L Light green.	2.0	0.5	2.5	0.5	4.0	2.0
M Dark green.	2.0	0.5	3.5	1.0	7.0	4.0
N Light blue.	1.5	1.0	4.0	2.0	7.5	5.0
O Dark blue..	3.0	1.0	4.5	1.0	7.0	2.0
P Light brown	2.3	1.0	4.3	1.2	7.0	5.0
Q Dark brown	1.3	0.0	4.5	1.0	9.5	2.0

*Stretch.

TABLE VII

Analysis of Variance of Shrinkage for Rayon and Wool Gabardines.

Source of variation	*Degrees of freedom*	*Mean square*
Fabrics (rayon, wool)	1	.04944
Dry cleanings (1, 5, 10, 15, 20, 25, 30 x)	6	.02966
Warp vs. filling	1	3.76898**
Fabrics x dry cleanings	6	.04243**
Fabrics x warp vs. filling	1	.28844**
Dry cleanings x warp vs. filling	6	.02053*
Remainder	202	.00756
Total	223	

*Significant (variation exceeded 5 per cent level)
**Very highly significant (variation exceeded 0.1 per cent level).

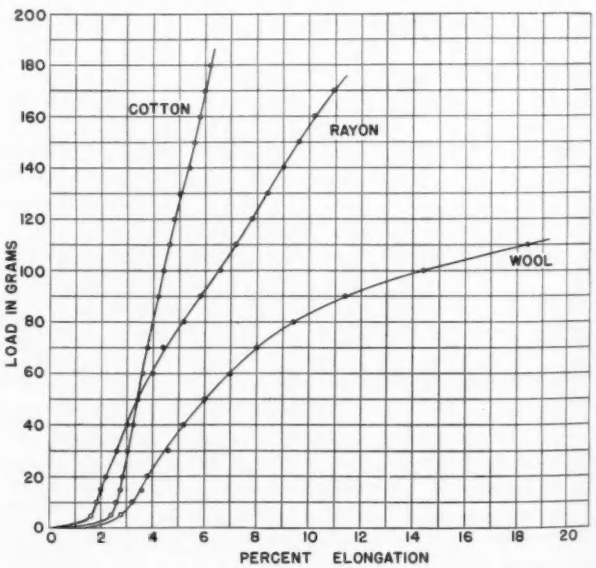

Fig. 1—Dynamic characteristics of a single-ply cotton yarn, a rayon warp yarn from the control of fabric D, and a wool warp yarn from the control of fabric N.

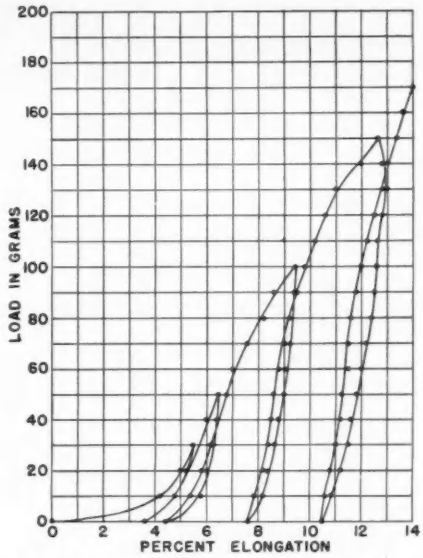

Fig. 2—Dynamic characteristic of a rayon warp yarn from the control of fabric H.

cotton. Wool had the most stretch and cotton the least. No sudden yielding occurred in the case of the wool, whereas the rayon showed a tendency for sudden yield points and exhibited some plastic flow.

Figures 2 and 3 show load-elongation curves with hysteresis loops taken at various points. As shown from Table I the yarn counts of the rayon and wool were about equal, and thus the hysteresis loops could be compared. In both cases the loops became wider the farther removed from the straight portion of the curve which was the region in which Hooke's law was most closely obeyed. The loops of the rayon were narrower which characterized a more wiry "feel." The wider loops for the wool indicated a softer "hand." The load-elongation curves for the yarns after 30 dry cleanings were similar to those of the controls. Thus, dry cleaning had no apparent effect on the dynamic properties of either.

Thermal Transmission

Table VIII gives the results on the thermal conductivity of the rayon and wool gabardines in calories transmitted by one cu. cm. of the fabric in one sec. of time at one degree centigrade difference in temperature. Table IX shows the results of the statistical analysis of the data. The rayon transmitted more heat than the wool fabrics. Dry cleaning did not affect the thermal transmission of either group. These results for thermal conductivity are somewhat higher than those given by Rees (14). Cook (15) found that fabrics increased in warmth after dry cleaning.

SUMMARY

The statistical analysis of the data on fading of the colored fabrics showed that neither the rayon nor the wool was superior. Dry cleaning had little effect on the color in both groups of fabrics. There was not a significant difference between fadings due to light and heat, but both produced considerably more fading than dry cleaning. The white rayon showed no change in color on exposure to light, but the wool turned yellow. On heating both turned, but the wool showed the greater color change.

The breaking strength of the rayon gabardine was greater than the wool gabardine. Moisture decreased the breaking strength of the wool less than that of the rayon, and the wool was more resistant to abrasion. Heat did not decrease the breaking strength of either significantly.

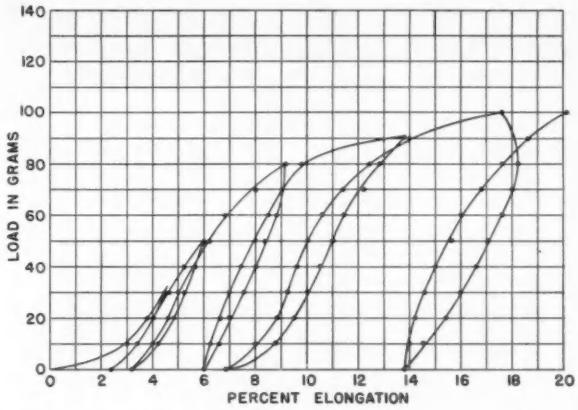

Fig. 3—Dynamic characteristic of a wool warp yarn from the control of fabric N.

TABLE VIII

Thermal Conductivity in Calories x 10^{-5}cm.$^{-1}$sec.$^{-1}$ deg. C.$^{-1}$ of the Controls and After 30 Dry Cleanings for Rayon and Wool Gabardines.

Fabrics	*Calories x 10^{-5}cm.$^{-1}$sec.$^{-1}$deg. C.$^{-1}$ Controls*	*30x dry-cleaned*
Rayon		
A Light red	22.2	22.6
B Dark red	19.6	21.8
C Light green	20.6	20.6
D Dark green	20.1	21.8
E Light blue	20.4	21.8
F Dark blue	20.7	22.2
G Light brown	19.7	21.3
H Dark brown	19.4	22.8
Wool		
J Light red	15.7	15.6
K Dark red	18.4	18.4
L Light green	18.6	19.8
M Dark green	16.2	16.2
N Light blue	16.2	15.6
O Dark blue	18.7	19.4
P Light brown	15.6	15.5
Q Dark brown	18.0	18.5

TABLE IX

Analysis of Variance of Thermal Conductivity for Rayon and Wool Gabardines.

Source of variation	*Degrees of freedom*	*Mean square*
Fabrics (rayon, wool)	1	117.045**
Dry cleanings (control, 30x)	1	5.951
Fabrics x dry cleanings	1	3.511
Remainder	28	1.629
Total	31	

**Very highly significant (variation exceeded 0.1 per cent level).

Light decreased the strength of the wool much more than that of the rayon.

When dry the wool had greater elongation than the rayon. Light, heat and abrasion decreased the elongation of wool more than that of the rayon. Moisture greatly increased the elongation of the wool gabardines but did not significantly change that of the rayon.

Dry cleaning did not decrease the breaking strength of the wool but decreased the rayon slightly. Dry cleaning did not affect the elongation.

There was no significant difference in shrinkage of the two groups of fabrics. Neither the wool nor the rayon gabardines shrank excessively with dry cleaning. Both shrank more in the warp than in the filling. The wool increased in shrinkage with successive dry cleanings, but the rayon did not.

The load-elongation curves showed that the rayon yarns were definitely different from the wool. The rayon showed a tendency for sudden yield points and exhibited some plastic flow, but the wool did not. The rayon was more wiry in "feel," and the wool had a softer "hand." Dry cleaning had no apparent affect on the dynamic properties of the yarns.

The thermal conductivity of the wool gabardines was definitely less than the rayon. Dry cleaning did not affect the conductivity of either group of fabrics.

ACKNOWLEDGMENT

Appreciation is expressed to Dr. H. C. Fryer, Statistician, Kansas Agricultural Experiment Station, for his assistance in the statistical analysis of the data.

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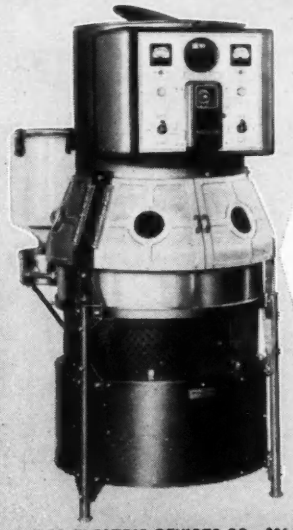

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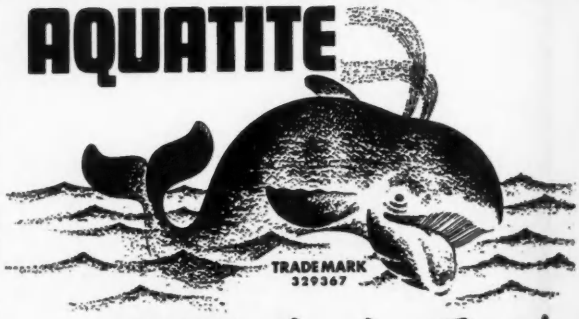

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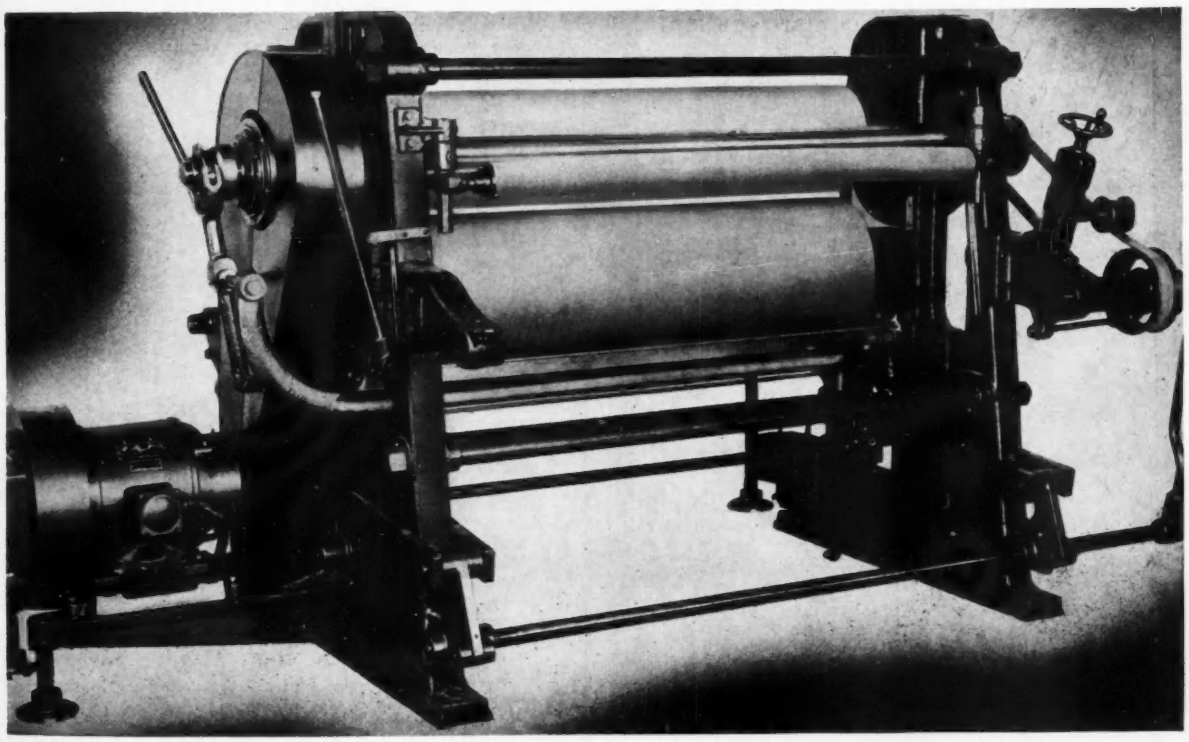

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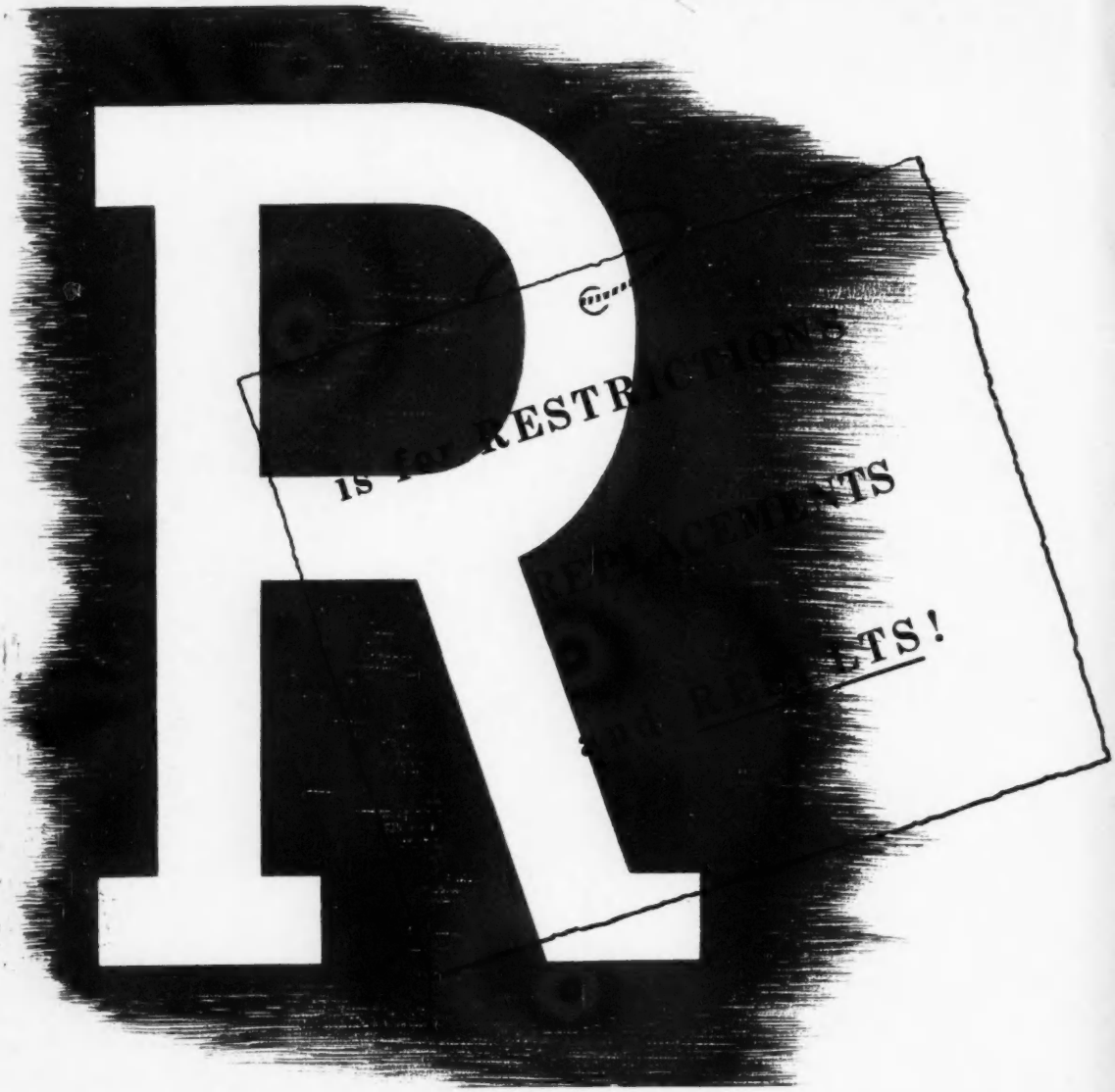

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